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HISTORY AND RESULTS OF PALAEONTOLOGICAL AND BIOSTRATIGRAPHIC RESEARCH AT THE STATE GEOLOGICAL INSTITUTE OF DIONÝZ ŠTÚR

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INTRODUCTION

Palaeontology is a science that deals with the study of fossils, or fossil remains of organisms, the evolution of life on Earth, its causes and natural laws. Stratigraphic geology is based on palaeontological knowledge, which plays a very important role in elucidating the geological and tectonic structure of areas formed by sedimentary rocks. Several geological disciplines are directly dependent on the level of its knowledge.

This paper brings in brief the most important and significant events related to the origin and development of the palaeontology at the State Geological Institute of Dionýz Štúr (ŠGÚDŠ), introduces the personalities of palaeontology and their work, which had a major impact on the development of this science not only within ŠGÚDŠ, but throughout Slovakia. Several specialists have gained a reputation beyond the borders of our country, as evidenced by their participation in international projects, participation in bilateral and trilateral cooperation projects, as well as their membership in various commissions. The palaeontologists have presented results of their research at many important international conferences, including international geological congresses. At home, visitors can get acquainted with their activities and the environment in which they work during the “Open Day”, which they organize every year in the ŠGÚDŠ premises. Some experts had been involved in research in North Africa, among them the excellent micropalaeontologist J. Salaj (Salaj, 1980). The cooperation of geologists with palaeontologists brought a significant improvement in the level of geological maps and was often a decisive element in the integration of rocks into individual formations, whether in the compilation of geological maps, evaluation of lithological profiles, boreholes, etc. Without the cooperation of geologists with palaeontologists, no new lithostratigraphic units or revisions of the previously defined ones would have been delineated. A detailed study of taxa has made it possible to identify new species of fossils or to emend them.

Fig. 1. Palaeontologists working at the State Geological Institute of D. Štúr.

The focus of palaeontologists (Fig. 1) was the study of many fossil groups of animal and plant origin: ammonites (D. Andrusov, M. Rakús, J. Pevný), bivalves and gastropods (D. Andrusov, M. Kochanová, J. Seneš, J. Papšová, A. Ondrejíčková, K. Fordinál), Quaternary malacofauna

(Z. Schmidt, J. Kernátsová), brachiopods (J. Pevný), corals (D. Andrusov), foraminifers (V. Kantorová, E. Brestenská, R. Lehotayová, M. Vaňová, J. Salaj, O. Samuel, V. Gašpariková, A. Zlinská, D. Boorová, K. Fekete), calpionellids (A. Kullmanová, D. Boorová, V. Borza Jr., K. Fekete), radiolarians (A. Ondrejíčková), ostracods (E. Brestenská, K. Fordinál, K. Kučerová, Ľ. Tuba), conodonts (J. Pevný, J. Papšová, Ľ. Gaál, M. Havrila, P. Straka), holothurians (J. Pevný, M. Havrila), calcareous nannoplankton (R. Lehotayová, V. Gašpariková, M. Potfaj, J. Raková, K. Žecová), palynomorphs (P. Snopková, E. Planderová, M. Papšíková, D. Suballyová, Z. Hlôšková, H. Vaněková), algae (J. Bystrický, S. Buček), dinoflagellate cysts (P. Snopková, O. Samuel), calcareous dinoflagellate cysts (D. Boorová), microfacies (A. Kullmanová, D. Boorová, K. Fekete, M. Mikudíková), vertebrates (Z. Schmidt, M. Vlačiky, M. Moravcová) and Palaeozoic amphibians (M. Mikudíková).

It is not possible to list all works, or the results of research brought by the fiddling work of palaeontologists working in the ŠGÚDŠ during its existence. In the years 1940 – 1949, this institution was called the State Geological Institute (ŠGÚ), later chronologically: 1949 – 1953 Slovak Central Institute of Geology (SÚÚG), 1953 – 1995 Dionýz Štúr Geological Institute (GÚDŠ), 1996 – 2000 Geological Survey of the Slovak Republic (GS SR) and from May 1, 2000 to the present Dionýz Štúr State Geological Institute (ŠGÚDŠ).

Dimitrij Andrusov (Fig. 1), the founder of the State Geological Institute, played a major role in the development of palaeontology and biostratigraphy in Slovakia. Right from the beginning of his research, he was aware of its importance for the solution of the geological setting of Slovakia.

After graduating from university, D. Andrusov began his scientific career as an assistant at the Geological and Palaeontological Institute of Charles University in Prague, where he joined in 1929. From the beginning of his geological research he paid great attention to biostratigraphy of Mesozoic (Andrusov, 1929, 1930, 1931) and Tertiary sediments (Andrusov, 1938, 1954) of the Western Carpathians and palaeontological research of various fossil groups of organisms, e.g. corals (Kühn & Andrusov, 1930, 1936), shellfish (Andrusov, 1932), ammonites (Andrusov, 1934; Andrusov & Kováčik, 1955), etc.

Palaeontological and biostratigraphic research played an important role in the State Geological Institute, which was reflected in its position in the first organizational structure in 1945. During this period, a separate palaeontological-stratigraphic department was established within the section of auxiliary departments headed by J. Kamenický. Palaeontologist V. Kantorová (née Navarová), who laid the foundations of micropalaeontology in Slovakia, was also included in this department.

DEVELOPMENT OF PALAEONTOLOGICAL AND BIOSTRATIGRAPHIC RESEARCH AND ITS RESULTS

Palaeontological and biostratigraphic research has been carried out at the ŠGÚ in Bratislava since its inception. Its development can be divided into four stages:

The first stage covers the period from 1940, it means from the foundation of the Institute to the beginning of the compilation of geological maps of Czechoslovakia at a scale of 1 : 200,000 in 1954.

The second stage is tied to the period of creation of geological maps at a scale of 1 : 200,000, between 1955 and 1960.

The third stage represents the period from the beginning of the compilation of geological maps at a scale of 1 : 25,000 and the creation of regional geological maps at a scale of 1 : 50,000. At this stage, there existed a separate department of biostratigraphy within the organizational structure of the Institute of Geology, and the biostratigraphic research reached its greatest prosperity and success. This phase covers the years 1961 to 1999.

The fourth stage dates back to 2000 and continues to present. This is a period of time during which the biostratigraphy has lost its position in geological research compared to previous periods. Although its importance has declined, it still remains an irreplaceable method at compiling the regional geological maps.

First stage (1940 – 1954)

The beginnings of the biostratigraphic research at the ŠGÚ are closely connected with regional geological mapping and the search for mineral resources.

Systematic geological research in Slovakia began with a geological mapping of the territory of the Žilina map sheet, which was published along with explanations in 1944 (Andrusov & Kuthan, 1944). As part of the mapping, a number of fossils from Mesozoic (ammonites, foraminifers) and Palaeogene (foraminifers, algae) sediments were found and determined in the territory of the said aforementioned map sheet. During this period, research focused on the occurrence of travertines in Slovakia. It was realized by Ľ. Ivan, an external employee of the Institute, who described in detail the findings of travertines known so far, in some cases also with the occurrence of fossil remains of flora and fauna (Ivan, 1943).

At the beginning of the 1950s, E. Brestenská mapped the territory of Central Ponitrie region, within which the presence of Karpathian (Helvetian) sediments in the Bánovská kotlina Basin was demonstrated for the first time in a microfaunistic way (Brestenská, 1953). During this period, one of the main tasks of the Institute was the reassessment of the raw material potential of Slovakia associated with the search for minerals. In addition, research on building materials and geological mapping was carried out in connection with research into the Neogene filling of the Danube and East Slovakian lowlands and the Flysch Zone, focusing on the occurrence of oil and natural gas. Micropalaeontology, which was dealt with by V. Kantorová at the time, was also applied in the previously mentioned works. This important expert evaluated the geological conditions of the marcasite deposit near Tepličany (Kantorová, 1950) and also collaborated on the evaluation of drilling works at the salt deposit near Prešov (Kantorová, 1952, 1954a). As part of the mapping of the Outer Flysch Zone, V. Kantorová processed the foraminifers' communities from Cretaceous sediments (Kantorová, 1956) and also participated in a prospecting survey for Mn-mineralization in Palaeogene sediments, in which she micropalaeontologically evaluated sediments exposed by the well near Kozelec (Kantorová, 1954b). As part of the geological mapping of southern and eastern Slovakia, R. Lehotayová (née Danihelová) studied micropalaeontologically surface samples from Oligocene and Miocene sediments (Danihelová, 1954a, b) and also participated in a survey focused on the occurrence of coal and mapping works in the East Slovakian Basin and Tokaj Mountains (Danihelová, 1955).

Second stage (1955 – 1960)

The beginning of the second stage can be limited to 1955, when the compilation of geological maps at a scale of 1 : 200,000 began. This project created a solid basis for the stabilization of geological activity at GÚDŠ. During the 50s of the 20th century, young graduates of the Faculty of Natural Sciences of SU, later the Faculty of Geological and Geographical Sciences of the Slovak University in Bratislava and Charles University in Prague were gradually entering the Institute. They were immediately participating in the solutions within the framework of this laborious project. To cope with this task, work teams in individual regional research departments began to be formed intensively. Work on the creation of geological maps at a scale of 1 : 200,000 had significantly accelerated the professional growth of several young geologists, including palaeontologists, who had been entrusted with responsible tasks in mapping and solving urgent stratigraphic and lithofacies issues.

In the compilation of individual map sheets at a scale of 1 : 200,000 participated the following palaeontologists: E. Brestenská, J. Bystrický, V. Gašpariková (née Čekalová), V. Kantorová, R. Lehotayová, A. Ondrejíčková, J. Papšová (née Volfová), E. Planderová, J. Salaj, O. Samuel, J. Seneš, P. Snopková and M. Vaňová (Fig. 1).

In addition to work on the compilation of geological maps at a scale of 1 : 200,000, geological research of Tertiary sediments in the vicinity of Kováčov was also carried out during this period as part of the search for Palaeogene coal deposits in the Danube Basin. As part of solving this task, Seneš (1958a, b) carried out a revision of the macrofauna of the Kováčov Mb., which he also systematically processed.

Third stage (1961 – 1999)

After the completion of the compilation of general maps of Czechoslovakia at a scale of 1 : 200,000, another stage of geological research was set out on the session of scientists and experts in Prague in 1961. It was agreed that the task of geological institutes in Czechoslovakia in the next stage will be to compile a new edition of map works at a scale of 1 : 50,000 on the basis of maps 1 : 25,000 (Grecula et al., 2006). The third stage of palaeontological and biostratigraphic research in ŠGÚDŠ is closely connected with this stage.

During the previous stage, palaeontologists from GÚDŠ and other geological institutions in Czechoslovakia acquired a large amount of palaeontological knowledge; individual experts wanted to inform their colleagues not only in writing in the form of publications and archival reports, but also personally consult each other theoretical, methodological and factual problems in palaeontological community. This effort resulted in the organization of palaeontological conferences. The first palaeontological conference took place in 1961 in Smolenice, Slovakia. The cycle of palaeontological conferences continues to this day (Fordinál et al., 2018).

In the 1960s, Cretaceous sediments were studied by Salaj (1960, 1962, 1963) and Palaeogene sediments by Samuel (1966a, b) as part of the compilation of geological maps at a scale of 1 : 25,000. The results of microbiostratigraphic research of the Cretaceous and Palaeogene sediments of the Western Carpathians were later summarized in two important monographs: Salaj & Samuel (1966) and Samuel & Salaj (1968), which were unique works at the time and can in fact be more or less utilised today.

The compilation of geological maps at a scale of 1 : 25,000 was carried out in the 1970s within the project "*Regional Geological Research of the Czechoslovak Socialist Republic, part Slovakia,* later *Regional Geological Research of the Czechoslovak Socialist Republic, Part the Western Carpathians, Slovakia*". The project was divided into several sub-tasks. Some of them focused on palaeontological and biostratigraphic issues in the compilation of individual regions. During the research of Strážovská hornatina and Považský Inovec Mts., the stratigraphy of Cretaceous sediments was studied (Gašpariková, 1976; Salaj, 1976), the processed macrofauna of Mesozoic sediments of the Western Carpathians (Kochanová, 1961, 1979; Kochanová & Pevný, 1976) and the Palaeogene rocks of Breznianska kotlina Basin (Papšová, 1978). Palynomorphs from flysch sediments were studied by Snopková (1975) and Schmidt (1976a, b, 1977) studied the malacofauna of the Lower Pohronie region and Ipeľská kotlina Basin.

As part of this regional project, a separate sub-task "*Palaeontological Research of Organisms Important for Stratigraphic and Facies Research of the Western Carpathians*" was allocated, which was not tied to any region and enabled the solution of palaeontological and biostratigraphic issues of individual groups of fossils. During this sub-task solution, significant findings were gained, which were later published either in the form of articles and in some cases in separate monographs.

During this task, Triassic brachiopods (Pevný, 1975) and foraminifers (Salaj & Samuel, 1978), Cretaceous foraminifers (Salaj & Samuel, 1976, 1977), calcareous nannoplankton (Gašpariková, 1977, 1979), Palaeogene foraminifers (Kantorová, 1976, 1978), Tertiary dinophlagellates (Snopková & Samuel, 1979), Palaeogene (Papšová, 1975, 1977) and Miocene molluscs (Ondrejíčková, 1975), Palaeogene (Snopková, 1978) and Neogene palynomorphs (Planderová, 1975, 1976), Neogene ostracods (Brestenská, 1978) and calcareous nannoplankton (Lehotayová, 1975, 1977). Quaternary octopuses (Schmidt, 1975) and molluscs (Schmidt, 1978) were also processed.

During this period, GÚDŠ staff also participated in the solution of the state basic research program *Palaeontological research (systematics, phylogeny and palaeoecology) of organisms important for stratigraphic and facies research of the main units of the Western Carpathians,* coordinated by the Geological Institute of the Slovak Academy of Sciences. This task was divided into 11 sub-tasks, of which 3 were solved by the GÚDŠ staff. These were the following sub-tasks: *Bivalves and gastropods of the Mesozoic of the Western Carpathians* (responsible solver M. Kochanová), *Study of foraminifers and nannoplankton of the Mesozoic and Tertiary* (responsible solver V. Gašpariková) and *Sporomorphs of the Palaeogene and Neogene* (responsible solver E. Planderová).

In the early 1970s, conodonts were obtained and studied for the first time from Triassic sediments from Slovakia (Budurov & Pevný, 1970). The fauna of Mesozoic molluscs from the locality Bleskový prameň at Drnava was processed in the form of monograph (Kollárová-Andrusovová & Kochanová, 1973).

In addition to the previously mentioned activities, the palaeontologists participated in the evaluation of important boreholes. In the 1970s, sediments from the boreholes SBM-1 Soblahov (Maheľ & Kullmanová, 1975), PU-1 Šambron (Nemčok et al., 1975), SV-1 Stará Voda (Ivanička et al., 1978), LX-5 Kremnica (Lexa et al., 1979) and others were microbiostratigraphically evaluated.

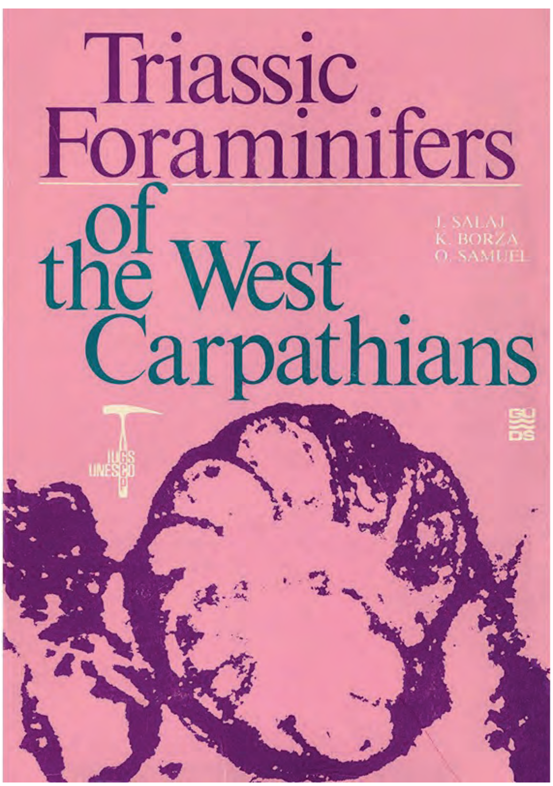

Fig. 2. Title page of a monograph on Triassic foraminifers by Salaj et al. (1983).

Work focused on palaeontological research continued at GÚDŠ in the 1980s through the task *Current Geological Issues of the Western Carpathians*. In the framework of this project index Triassic fossils were processed: brachiopods (Pevný et al., 1984) and foraminifers (Salaj et al., 1982, 1983; Fig. 2), Cretaceous: foraminifers (Samuel & Gašpariková, 1984), Palaeogene: molluscs (Papšová, 1983), foraminifers (Samuel, 1983; Vaňová, 1983) and palynomorphs (Snopková, 1983). Foraminifers, ostracods, molluscs, calcareous nannoplankton and palynomorphs of the Lower Miocene have also been studied (Planderová et al., 1984). In addition to the above topics, during the task *Regional Geological Research SSR, IInd Stage,* selected Mesozoic profiles were evaluated biostratigraphically based on microfauna and ammonites (Kullmanová et al., 1984) and conodonts (Papšová, 1984).

During this period, the palaeontologists participated in the project *Geological Exploration of Mineral Resources in Selected Areas of the* SSR in a prognostic deposit survey for lignite (Vass et al., 1984) and were co-investigators of the sub-task *Geological Prospecting and Deposit Evaluation of Marine and Ocean Solid Minerals* (Horniš et al., 1982; Zlinská, 1983).

In 1985, IIIrd stage of the project *Regional Geological Research of Slovakia*. As part of its partial task "*General Geological Maps of the Thematic Focus in the Territory of SSR*", the palaeontologists solved the current problems of the stratigraphy of the Western Carpathians. Cephalopods from the olistoliths of the Rača unit were processed (Rakús, 1985, 1987), macrofauna of the Carboniferous age from Dobšiná (Vaňová, 1986), Jurassic and Cretaceous radiolarians (Ondrejíčková, 1986), foraminifers, calcareous nannoplankton and palynomorphs from Lias to Oligocene sediments (Gašpariková, 1986; Snopková, 1986) and calcareous nannoplankton from the Upper Badenian sediments of the Danube Lowland (Lehotayová, 1985). In addition to the above-mentioned works, microbiostratigraphy of the Cretaceous of the Klippen Belt (Samuel et al., 1988), stratigraphy of the Tertiary of the Turčianska kotlina Basin (Gašpariková et al., 1988) and the Upper Miocene of Bratislava (Fordinál & Tuba, 1988) were processed in 1988.

As part of the departmental task "*Tasks of International Scientific and Technical Cooperation in the Field of Geological Research*", biozonation of Palaeogene sediments was performed on the basis of foraminifera (Samuel, 1987).

In 1988, the IVth stage of the project *Regional Geological Research SSR* was commenced. During the solution of the partial task "*Geological map of SSR 1 : 500,000*" the radiolarian of the Triassic and Jurassic of the Slovak Karst were studied (Ondrejíčková, 1990), microbiostratigraphic and microfacies evaluation of the Cretaceous sequences of the Manín Unit in the Belušské Slatiny profile was performed (Boorová, 1989) as well as the Urgonian facies s. l. at other localities of the Manín and Krížna units (Boorová, 1990), the microfauna and microflora of Globigerina marls of the Malcov Formation in eastern Slovakia was evaluated (Gašpariková & Snopková, 1989), the stratigraphy of the Neogene sediments of Slanské vrchy Mts. and Košická kotlina Basin (Zlinská & Fordinál, 1989) as well as Upper Miocene sediments from the territory of Bratislava (Fordinál et al., 1990).

At the end of the 1980s, the microflora of the Miocene sediments of the Western Carpathians was comprehensively processed by E. Planderová (1990; Fig. 3).

Based on planktonic foraminifers, zoning of the Butkov Formation of the Manín Unit was carried out (Boorová & Salaj, 1992).

In 1994, the 5th stage of the *Regional Geological Research of Slovakia* project began, which was divided into several sub-tasks. Palaeontology and biostratigraphy were solved within the partial task "*Biostratigraphy of the Phanerozoic of the Western Carpathians*". Attention was paid to the processing of Palaeozoic palynomorphs (Hlôšková, 1995) and Triassic profiles (Havrila, 1997; Havrila et al., 1995). The fauna of Jurassic sediments was also studied (Fordinál & Potfaj, 1996; Potfaj et al., 1998; Rakús, 1996), selected Cretaceous profiles were evaluated from the microfacies and biostratigraphic points of view (Boorová, 1998; Boorová & Potfaj, 1997) and fossil communities were processed from the Neogene sediments of Slovakia (Fordinál, 1998; Zlinská, 1997; Zlinská, 1998).

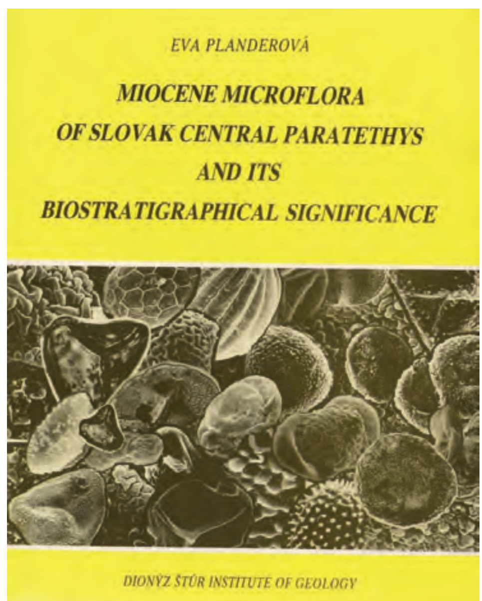

Fig. 3. Title page of E. Planderová's (1990) monograph on the Miocene microflora.

Fourth stage (2000 – present)

During this time, the Biostratigraphy Department in ŠGÚDŠ was abolished. Palaeontology and biostratigraphy have become only auxiliary methods in regional geological research. Despite these facts, biostratigraphic research continues to play an irreplaceable role in Slovakia's regional geological research. The results of the biostratigraphic research are used in the age classification of sedimentary rocks, in the compilation of regional geological maps and explanations to them (Gross et al., 1999; Ivanička et al., 2011; Bóna et al., 2008; Mello et al., 2011; Kováčik et al., 2011; Polák et al., 2012; Fordinál et al., 2012; Kováčik et al., 2015; Teťák et al., 2016; Maglay et al., 2017) and biostratigraphic evaluation of sediments from hydrogeological wells (Marcin, 2009; Zlinská, 2009; Mikuláš et al., 2013; Černák et al., 2012). To a lesser extent, partial tasks focused on e.g. for palaeoclimatic research (Kernátsová et al., 2004) were solved, as well.

As part of the project *Update of the Geological Structure of Problem Areas of the Slovak Republic at a Scale of 1 : 50,000*, sediments of the Triassic and Lower Jurassic (Lias) at the SE edge of Muránska planina Plateau were studied during reambulation mapping works (Kronome & Boorová, 2014), Cretaceous sediments of the Párnica Formation were evaluated at several sites (Boorová & Filo, 2009, 2013, 2014, 2016), stratigraphy of Palaeogene and Neogene sediments from the Handlovská kotlina Basin was re-evaluated (Zlinská, 2013; Zlinská & Gross, 2013), deep oil wells were re-assessed from the Danube Basin (Zlinská, 2016, 2017), climatography, paleoenvironmental development and isotope analysis of important Quaternary localities of the Slovak Republic (Šefčík et al., 2019).

Biostratigraphic and microfacies research of Mesozoic sequences at the Schrambachgraben site in the Northern Limestone Alps took place in a tripartite collaboration (Boorová et al., 2015).

Recently, the palaeontologists have participated in the research of the Manín Unit (Fekete et al., 2017) and the study of upper Cretaceous olistoliths in Považský Inovec Mts. was completed (Pelech et al., 2021).

At ŠGÚDŠ, it was possible to consult and correlate the results of our palaeontological and biostratigraphic research not only with the Slovak specialists but also the foreign ones within the palaeontological conferences in 2004, 2007, 2011 and 2022 (Zlinská, 2004, 2007; Boorová, 2011; Fekete, 2022).

CONCLUSIONS

The palaeontology has experienced a significant retreat from its positions in recent years, due to several aspects. After the departure of the first generation of palaeontologists who joined the ŠGÚ in the 1950s, their gradual reduction took place. The emerging young generation of palaeontologists no longer had the same favourable working conditions for development as its predecessors. The social situation in Slovakia has also changed and there is currently very little interest in studying palaeontology, and geology in general. The reasons should be sought not only in the complexity of the study, but also in the ever-decreasing possibility of employment in the given field as well as the insufficient financial evaluation of researchers. Another reason is the small number of projects and their insufficient financial support in the framework of which the palaeontologists could apply and develop their knowledge and skills, as well as an insufficient instrumentation.

Despite these negative phenomena that currently affect this scientific field, it is necessary to express the conviction that there will be enthusiasts of palaeontology and geology in the present as well as in the near future, who will try to elevate it to positions to which these disciplines undoubtedly rightfully ought to be ranked.

Translated by Pavel Liščák

References:

Andrusov, D., 1929: Příspěvky ke geologii severozápadních Karpat – II. O stáří vrstev púchovských. [Contributions to the geology of the Northwest Carpathians – II. About the age of the Púchov Mb.]. *Věst. St. geol. Úst*., 5, 1, 26–36 [In Czech].

Andrusov, D., 1930: Příspěvky ke geologii severozápadních Karpat – VI. Stratigrafické rozdělení bradlového obalu. [Contributions to the geology of the Northwest Carpathians – VI. Stratigraphic division of the Klippen Belt cover]. *Věst. St. geol. Úst.*, 6, 4–6, 221–232 [In Czech].

Andrusov, D., 1931: O stratigrafickém rozdělení spodní křídy subtatranského příkrovu na středním Slovensku. [On the stratigraphic division of the lower Cretaceous of the Sub-Tatric Nappe in central Slovakia]. *Věst. St. geol. Úst.*, 7, 2, 152–160 [In Czech].

Andrusov, D., 1932: O některých jurských inoceramech z československých Západních Karpat. [About some Jurassic inocerams from the Czechoslovak Western Carpathians]. *Věst. St. geol. Úst. Čs. Republ.*, 8, 292–294 [In Czech].

Andrusov, D., 1934: O nálezu ammonoidea v karpatském rhaetu. [About the finding of ammonoid in the Carpathian Rhaetian]. *Věst. St. geol. Úst. Čs. Republ.*, 10, 9–12 [In Czech].

Andrusov, D., 1938: Karpathen – Miozän und Wiener Becken. *Petroleum,* 34, 1–9.

Andrusov, D., 1954: O veku výplne Turčianskej kotliny a o vývine pliocénu na strednom Slovensku. [About the age of the Turčianska kotlina Basin and the development of the Pliocene in central Slovakia]. *Geol. Sbor.,* 5, 1–4, 255–269. [In Slovak].

Andrusov, D. & Kováčik, J., 1955: Skameneliny karpatských druhohôr. Časť II. Hlavonožce triasu Slovenska a rozdelenie slovenského triasu. [Fossils of the Carpathian Mesozoic. Part II. Cephalopods of the Slovak Triassic and the division of the Slovak Triassic]. *Geol. Sbor.,* 6, 3–4, 258–301. [In Slovak].

Andrusov, D. & Kuthan, M., 1944: Vysvetlivky ku geologickej mape Slovenska. List Žilina (4361/2). [Explanations to the geological map of Slovakia. Map sheet Žilina (4361/2)]. *Práce Št. geol.* Úst*.*, Soš., 10 (Bratislava), 196 p. [In Slovak].

Bóna, J., Gazdačko, Ľ., Kobulský, J., Maglay, J., Kučera, M., Žecová, K., Derco, J., Zlinská, A., Siráňová, Z., Boorová, D., Kováčik, M., Buček, S. & Vaněková, H., 2008: Geologická mapa južnej časti regiónu „Nízke Beskydy – západná časť" v mierke 1 : 25 000, listy

28-313, 28-314, 28-331, 28-332, časti mapových listov 27-424, 27-442) [Geological map of the southern part of the region "Nízke Beskydy Mts. – western part" in scale 1 : 25,000, map sheets 28-313, 28-314, 28-331, 28-332, parts of map sheets 27-424, 27-442)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Boorová, D., 1989: Mikrofaciálne a mikrobiostratigrafické zhodnotenie kriedových sekvencií v profile Belušské Slatiny. [Microfacies and microbiostratigraphic evaluation of Cretaceous sequences in the Belušské Slatiny profile]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Boorová, D., 1990: Štúdium urgónskej fácie manínskej jednotky a krížňanskej jednotky. [Study of the Urgon facies of the Manin unit and the Křížňany unit]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Boorová, D., 1998: Biostratigrafické a mikrofaciálne vyhodnotenie a korelácia vybraných kriedových profilov Západných Karpát. Biostratigrafické vyhodnotenie profilu Rochovica. [Biostratigraphic and microfacies evaluation and correlation of selected Cretaceous profiles of the Western Carpathians. Biostratigraphic evaluation of the Rochovica profile]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Boorová, D. (ed.), 2011: 12. paleontologická konferencia. Zborník príspevkov, Bratislava, Slovenská republika, 20. – 21. októbra 2011. Konferencie, Sympózié, Semináre. [12th Palaeontological conference. Proceedings, Bratislava, Slovak Republic, October 20 – 21, 2011. Conferences, Symposia, Seminars]. Bratislava, St. Geol. Inst. D. Štúr, 110 p. [In Slovak].

Boorová, D. & Filo, I., 2009: Litologické, mikrofaciálne a mikrobiostratigrafické štúdium sedimentov staršej kriedy fatrika (Lúčky – Hlboké). [Lithological, microfacies and microbiostratigraphic study of sediments of the older Cretaceous of Fatricum (Lúčky – Hlboké)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Boorová, D. & Filo, I., 2013: Štúdium párnického súvrstvia na stratotypovom profile Žaškov (krížňanský príkrov). [Study of the Párnica Formation on the stratotype profile of Žaškov (Krížna Nappe)]. *Miner. Slov.,* 45, 61–68 [In Slovak with English abstract].

Boorová, D. & Filo, I., 2014: Litologické, mikrofaciálne a biostratigrafické štúdium párnického súvrstvia na lokalite Kraľovany (krížňanský príkrov, Západné Karpaty). [Lithological, microfacies and biostratigraphic study of the Párnica Formation in the Kraľovany locality (Krížna Nappe, Western Carpathians)]. *Geol. Práce, Spr.*, 123, 41–77.

Boorová, D. & Filo, I., 2016: Litologické, mikrofaciálne a biostratigrafické štúdium párnického súvrstvia v okolí Vlkolínca (stratotypová lokalita vlkolínskej brekcie, krížňanský príkrov fatrika, Západné Karpaty). [Lithological, microfacies and biostratigraphic study of the Párnica Formation in the vicinity of Vlkolínec (stratotype locality of the Vlkolínec breccia, Krížna nappe, Western Carpathians)]. *Geol. Práce, Spr.,* 129, 7–34.

Boorová, D. & Potfaj, M., 1997: Biostratigraphical and lithological evaluation of the profile "Balcová", Šiprúň sequence, Veľká Fatra Mts. *Slovak Geol. Mag.,* 3, 4, 315–329.

Boorová, D. & Salaj, J., 1992: Remarks of the biostratigraphy of the Butkov Formation in the Manín Sequence. *Geol. Carpath.,* 43, 2, 123–126.

Boorová, D., Skupien, P., Vašíček, Z. & Lobitzer, H., 2015: Biostratigraphy of the Lower Cretaceous Schrambach Formation on the classical locality of Schrambachgraben (Northern Calcareous Alps, Salzburg Area). *Bull. Geosci.,* 90, 189–131.

Brestenská, E., 1953: Zpráva o geológii terciéru stredného Ponitria. [Report on the geology of the Tertiary Central Ponitrie region]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Brestenská, E., 1978: Taxonómia ostrakód bádenu. [Taxonomy of the Badenian ostracods]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Budurov, K. & Pevný, J., 1970: Über die Anwesenheit von Trias-Conodonten in den Westkarpaten. *Geol. Práce, Spr., 51*, 165–171.

Černák, R., Remšík, A., Malík, P., Kordík, J., Michalko, J., Bajtoš, P., Baráth, I., Boorová, D., Bottlik, F., Buček, S., Elečko, M., Filo, I., Gregor, M., Jankulár, M., Kohút, M., Lenhardtová, E., Marcin, D., Olšavský, M., Ondrejka, P., Polák, M., Siráňová, Z., Šimon, L., Zlinská, A., Žecová, K., Filo, I., Gretsch, J., Gyurusi, C., Mikuška, J., Olejník, M., Pašteka, R. & Šivo, A., 2012: Základný hydrogeologický výskum Handlovskej kotliny. [Basic hydrogeological research of the Handlovská kotlina Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak with English summary].

Danihelová, R. H., 1954a: Predbežná zpráva o mikrofaune juhoslovenského oligocénu. [Preliminary report on the microfauna of the South Slovakia Oligocene]. *Geol. Práce, Zpr.,* 1, 88–89 [In Slovak].

Danihelová, R. H., 1954b: Predbežná zpráva o mikropaleontologickom výskume východoslovenského neogénu. [Preliminary report on micropalaeontological research of the East Slovak Neogene]. *Geol. Práce, Zpr.,* 1, 103 p. [In Slovak].

Danihelová, R. H., 1955: Zpráva o mikrofaune zo strednej a západnej časti Prešovsko-Tokajského pohoria. [Report on microfauna from the central and western part of the Prešov-Tokaj mountains]. *Geol. Práce, Zpr.,* 4, 72–77 [In Slovak].

Fekete, K. (Ed.), 2022: 21st Slovak-Czech-Polish Paleontological Conference. Field Trip Guide and Abstracts Book. *Bratislava, St. Geol. Inst. D. Štúr,* 1–220. ISBN 978-80-8174-064-0.

Fekete, K., Soták, J., Boorová, D., Lintnerová, O., Michalík, J. & Grabowski, J., 2017: An Albian demise of the carbonate platform in the Manín Unit (Western Carpathians, Slovakia). *Geol. Carpath.,* 68, 5, 385–402.

Fordinál, K., 1998: Mäkkýše sladkovodných vrchnomiocénnych sedimentov Západných Karpát. [Molluscs of freshwater Upper Miocene sediments of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Fordinál, K., Brzobohatý, R. & Michalík, J., 2018: História a význam paleontologických konferencií v Československu a v Českej a Slovenskej republike. [History and significance of Palaeontological conferences in Czechoslovakia and in the Czech and Slovak Republics]. *Geol. Práce, Spr.,* 132, 59–70.

Fordinál, K. (ed.), Maglay, J., Elečko, M., Nagy, A., Moravcová, M., Vlačiky, M., Kohút, M., Németh, Z., Bezák, V., Polák, M., Plašienka, D., Olšavský, M., Buček, S., Havrila, M., Hók, J., Pešková, I., Kucharič, Ľ., Kubeš, P., Malík, P., Baláž, P., Liščák, P., Madarás, J., Šefčík, P., Baráth, I., Boorová, D., Uher, P., Zlinská, A. & Žecová, K., 2012: Vysvetlivky ku geologickej mape Záhorskej nížiny 1 : 50 000. [Explanations to the geological map of the Záhorská nížina Lowland 1 : 50,000]. Bratislava, St. Geol. Inst. D. Štúr, 7–232.

Fordinál, K., Mataniová, D. & Tuba, Ľ., 1990: Ekostratigrafia vrchného miocénu a pliocénu Bratislavy. [Ecostratigraphy of the Upper Miocene and Pliocene of Bratislava]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Fordinál, K. & Potfaj, M., 1996: Amonity mladšej jury Západných Karpát. [Ammonites of the Younger Jurassic of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Fordinál, K. & Tuba, Ľ., 1988: Ekostratigrafia panónu a pontu veľkej Bratislavy na základe mäkkýšov a ostrakód. [Ecostratigraphy of the Pannonian and Pontian of Greater Bratislava on the basis of molluscs and ostracods]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Gašpariková, V., 1976: Stratigrafia kriedy v Strážovskej hornatine na základe foraminifer a vápnitého nanoplanktónu. [Cretaceous stratigraphy in Strážovská hornatina Mts. based on foraminifers and calcareous nannoplankton]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Gašpariková, V., 1977: Zonálne členenie kriedy Západných Karpát na základe nanoplanktónu. [Zonal division of the Western Carpathians Cretaceous based on nannoplankton]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Gašpariková, V., 1979: Korelácia kokolitoforidných zón kriedy Západných Karpát s mediteránnou oblasťou. [Correlation of the coccolithophores zones of the Western Carpathians Cretaceous with the Mediterranean region]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Gašpariková, V., 1986: Mikrofaunistická charakteristika sedimentov Ľubovnianskej vrchoviny. [Microfaunistic characteristics of sediments of the Ľubovnianska vrchovina Highlands]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Gašpariková, V., Planderová, E., Samuel, O., Snopková, P. & Vaňová, M., 1988: Ekostratigrafia terciéru Turčianskej kotliny. [Ecostratigraphy of the Tertiary of the Turčianska kotlina Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Gašpariková, V. & Snopková, P., 1989: Korelácia mikrofauny, nanoflóry a mikroflóry z globigerinových slieňov malcovského súvrstvia na východnom Slovensku. [Correlation of microfauna, nannoflora and microflora from Globigerina marls of the Malcov Formation in eastern Slovakia]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Grecula, P., Bartalský, J., Cambel, B., Herčko, I., Kaličiak, M., Matula, M., Melioris, L., Polakovič, D., Slavkay, M., Sombathy, L. & Šefara, J., 2006: História geológie na Slovensku. [History of geology in Slovakia]. Vol. 2. Bratislava, St. Geol. Inst. D. Štúr, 942 p. [In Slovak].
Gross, P. (ed.), Buček, S., Ďurkovič, T., Filo, I., Maglay, J., Halouzka, R., Karoli, S., Nagy, A., Spišák, Z., Žec, B., Vozár, J., Borza, V., Lukáčik, E., Janočko, J., Jetel, J., Kubeš, P., Kováčik, M., Žáková, E., Mello, J., Polák, M., Siráňová, Z., Samuel, O., Snopková, P., Raková, J., Zlinská, A. & Vozárová, A. & Žecová, K., 1999: Vysvetlivky ku geologickej mape Popradskej kotliny, Hornádskej kotliny, Levočských vrchov, Bachurne a Spišsko--šarišskej vrchoviny 1 : 50 000. [Explanations to the geological map of the Popradská kotlina Basin, the Hornádska kotlina Basin, the Levočské vrchy Mts., Bachureň Mts. and the Spišsko-šarišská vrchovina Highlands 1 : 50,000]. Bratislava, GS SR, 7–239.
Havrila, M., 1997: Progradácia rífového komplexu hronika. [Progression of the reef Hronicum complex]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Havrila, M., Šabíková-Hlôšková, Z., Borza, V., Buček, S. & Pevný, J., 1995: Biostratigrafické vyhodnotenie triasových profilov hronika. [Biostratigraphic evaluation of Triassic profiles of Hronicum]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Hlôšková, Z., 1995: Výskum palynomorf paleozoika na vybraných profiloch, korelácia s inými skupinami. I. časť. Paleozoické palynomorfy v ZK – výsledky doterajších výskumov, korelácia a perspektívy. [Palaeozoic palynomorph research on selected profiles, correlation with other groups. Part I. Palaeozoic palynomorphs in Western Carpathians – results of previous research, correlation and perspectives]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Horniš, J., Határ, J., Krištín, J., Kantorová, V., Samuel, O. & Lehotayová, R., 1982: Výsledky expedície Pacifik ‚81 – “Georgij Maksimov”. [Results of the Pacific ‘81 expedition – “Georgij Maksimov”]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].
Ivan, Ľ., 1943: Výskyty travertínov na Slovensku. [Occurrences of travertines in Slovakia]. *Práce Štát. geol. Úst.*, Soš., 9, 71 p.
Ivanička, J., Kohút, M. (eds.), Havrila, M., Olšavský, M., Hók, J., Kováčik, M., Madarás, J., Polák, M., † Rakús, M., Filo, I., Elečko, M., Fordinál, K., Maglay, J., Pristaš, J., Buček, S., Šimon, L., Kubeš, P., Scherer, S., Zuberec, J., Dananaj, I., Klukanová, A., Konečný, P., Boorová, D., † Siráňová, Z., Zlinská, A. & Žecová, K., 2011: Vysvetlivky ku geologickej

mape Považského Inovca a jv. časti Trenčianskej kotliny. [Explanatory notes to the geological map of Považský Inovec Mts. and SE part of the Trenčianska kotlina Basin]. Bratislava, St. Geol. Inst. D. Štúr, 7–389.

Ivanička, J., Vozárová, A., Chmelík, J., Hanzel, V., Snopková, P. Kupčo, G. & Beňka, J., 1978: Správa za hlboký štruktúrny vrt SV-1 Stará Voda. [Report for the deep structural well SV-1 Stará Voda]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kantorová, V., 1950: Zpráva o geologickom mapovaní v okolí Tepličian. [Report on geological mapping in the vicinity of Tepličany]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kantorová, V., 1952: Zhodnotenie doterajšieho vrtného prieskumu soľného ložiska pri Prešove. [Evaluation of the current drilling survey of the salt deposit near Prešov]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kantorová, V., 1954a: Mikropaleontologický výskum prešovského solinosného miocénu. [Micropalaeontological research of Prešov salt-bearing Miocene]. *Geol. Práce, Zpr.,* 1, 91–93 [In Slovak].

Kantorová, V., 1954b: Mikropaleontologický výskum podtatranského flyša. [Micropalaeontological research of the Subtatric flysch]. *Geol. Práce, Zpr.,* 1, 78–79 [In Slovak].

Kantorová, V., 1956: O takzvanej inocerámovej kriede v okolí Sniny. [About the so-called inoceramic Cretaceous around Snina]. *Geol. Práce, Zpr.,* 9, 52–63 [In Slovak].

Kantorová, V., 1976: Morfológia a taxonómia planktonických foraminifer rupelu. [Morphology and taxonomy of planktonic foraminifers of Rupelian]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kantorová, V., 1978: Morfológia a taxonómia malých foraminifer oligocénu a ich životné prostredie. [Morphology and taxonomy of Oligocene small foraminifers and their environment]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kernátsová, J., Fordinál., K., Maglay, J., Vaněková, H. & Harčová, E., 2004: Paleoklimatický vývoj Západných Karpát v období terciéru a kvartéru na základe sledovania zmien v charaktere sedimentácie a biologických spoločenstiev. [Palaeoclimatic development of the Western Carpathians in the Tertiary and Quaternary periods based on monitoring changes in the character of sedimentation and biological communities]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kochanová, M., 1961: Niekoľko paleontologických lokalít spodného liasu z oblasti Čierneho vrchu pri Čiernej Lehote v Strážovskej hornatine. [Several palaeontological localities of the Lower Lias from the Čierny vrch area near Čierna Lehota in the Strážovská hornatina Mts.]. *Geol. Práce, Zpr.,* 22, 99–126 [In Slovak].

Kochanová, M., 1979: Stratigrafia stredného a vrchného triasu pomocou bivalvií a gastropódov v Slovenskom krase a v niektorých pohoriach centrálnych Západných Karpát. [Stratigraphy of the Middle and Upper Triassic using bivalves and gastropods in the Slovak Karst and in some mountains of the central Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kochanová, M & Pevný, J., 1976: Biostratigrafické vyhodnotenie makrofauny (Bivalvie, gastropódy, brachiopódy) východnej časti Strážovskej hornatiny. [Biostratigraphic evaluation of macrofauna (bivalves, gastropods, brachiopods) of the eastern part of the Strážovská hornatina Mts.]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kollárová-Andrusovová, V. & Kochanová, M., 1973: Molluskenfauna des Bleskový prameň bei Drnava (Nor, Westkarpaten). Bratislava, *Vyd. Slov. Akad. Vied,* 215 p.

Kováčik, M. (Ke), M., Bóna, J., Gazdačko, Ľ., Kobulský, J., Maglay, J., Kučera, M., Žecová, K., Derco, J., Zlinská, A., Siráňová, Z., Boorová, D., Bónová, K., Buček, S., Kucharič, Ľ., Bačová, N., Petro, Ľ. & Vaněková, H., 2011: Vysvetlivky ku geologickej mape regiónu „Nízke Beskydy – západná časť" v mierke 1 : 50 000 (mapový list 28-31 (Svidník) a časti mapových listov 27-24 (Zborov), 27-42 (Bardejov), 27-44 (Sabinov), 28-13 (Vyšný Mirošov) a 28-33 (Giraltovce). [Explanatory notes to the geological map of the region "Nízke Beskydy Mts. – western part" in the scale 1 : 50,000 (map sheet 28-31 (Svidník) and parts of map sheets 27-24 (Zborov), 27-42 (Bardejov), 27-44 (Sabinov), 28-13 (Vyšný Mirošov) and 28-33 (Giraltovce)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kováčik, M., Kohút, M., Havrila, M., Boorová, D., Filo, I., Sentpetery, M., Laurinc, D., Olšavský, M., Maglay, J., Nagy, A., Nagy, A., Šimon, L., Kollárová, V., Kováčiková, M., Baráth, I., Žecová, K., Zlinská, A., Černák, R., Kordík, J., Šoltés, S., Kucharič, Ľ., Liščák, P. & Gluch, A., 2015: Vysvetlivky ku geologickej mape Žiaru 1 : 50 000. [Explanations to the geological map of Žiar Mts. in the scale 1 : 50,000]. Bratislava, St. Geol. Inst. D. Štúr, 420 p. [In Slovak with English summary].

Kronome, B. & Boorová, D., 2014: Geologická stavba masívu Tesnej skaly (Muránska planina, centrálne Západné Karpaty) – výsledky geologického mapovania a biostratigrafického štúdia. [Geological structure of the Tesná skala massif (Muránska planina Plateau, Central Western Carpathians) – results of geological mapping and biostratigraphic study]. *Geol. Práce, Spr.,* 129, 7–29. [In Slovak with English abstract].

Kullmanová, A., Rakús, M., Biely, A., Pevný, J. & Havrila, M., 1984: Charakteristické litostratigrafické profily mezozoika Nízkych Tatier. Časť II (mezozoikum chočského a štureckého príkrovu). [Characteristic lithostratigraphic profiles of the Mesozoic of the Nízke Tatry Mts. Part II (Mesozoic of the Choč and Šturec nappes)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Kühn, J. & Andrusov, D., 1930: Korallen aus der Klippenhülle der Karpathen. *Věst. St. geol. Úst.*, 6, 4–6, 155–168.

Kühn, J. & Andrusov, D., 1936: Weitere Korallen aus Oberkreide der Westkarpathen. *Věst. Král. Čes. Společ. Nauk, Tř. mat.-přírodověd*., 9, 1–18.

Lehotayová, R., 1975: Biostratigrafické a taxonomické štúdiá vápnitej nanoflóry neogénu Západných Karpát. [Biostratigraphic and taxonomic studies of the calcareous nannoflora of the Neogene of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Lehotayová, R., 1977: Systematika a ekológia vápnitej nanoflóry bádenu. [Systematics and ecology of the calcareous nannoflora of Badenian]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Lehotayová, R., 1985: Biostratigrafia, systematika a ekológia vrchného bádenu Podunajskej nížiny, najmä v oblasti veľkej Bratislavy na základe vápnitej nanoflóry. [Biostratigraphy, systematics and ecology of the Upper Badenian of the Danubian Plain, especially in the Greater Bratislava area based on calcareous nannoflora]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Lexa, J., Dovina, V., Planderová, E., Lehotayová, R., Vaňová, M., Dudáš, J. & Noghe, V., 1979: Vyhodnotenie štruktúrneho vrtu LX-5 (Kremnica). [Evaluation of structural well LX-5 (Kremnica)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Maglay, J., Fordinál, K., Nagy, A., Kováčik, M., Šefčík, P., Vlačiky, M., Šimon, L., Moravcová, M., Zlocha, M., Fričovská, J., Zlinská, A., Žecová, K., Baráth, I., Liščák, P., Ondrášiková, B., Gluch, A., Kucharič, Ľ., Zeman, I., Kubeš, P., Benková, K., Bottlik, F., Marcin, D., Michalko, J., Baláž, P., Stupák, J. & Tuček, Ľ., 2017: Vysvetlivky ku geologickej mape regiónu Podunajská nížina – Podunajská rovina v mierke 1 : 50 000. [Explanatory notes to the geological map of the Danubian Lowland – Danubian Plain region at a scale of 1: 50,000]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Maheľ, M. & Kullmanová, A., 1975: Komplexné vyhodnotenie štruktúrneho vrtu SBM-1 Soblahov. [Comprehensive evaluation of the structural well SBM-1 Soblahov]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Marcin, D., Elečko, M., Polák, M., Boorová, D., Zlinská, A., Malík, P., Michalko, J., Švasta, J., Kordík, J., Krčmová, K., Maďar, D., Kubeš, P., Kucharič, Ľ., Pašteka, R., Olejník, M., Hodák, Ľ., Bottlik, F., Černák, R., Gregor, M., Bačová, N., Lenhardtová, E., Hrdlovič, R., Repková, R., Juhás, M., Makovinská, J., Kráľ, J., Čech, P., Harčová, E. & Gluch, A., 2009: Hydrogeotermálne zhodnotenie Rimavskej kotliny, regionálny geologický výskum. [Hydrogeothermal evaluation of the Rimavská kotlina Basin, regional geological research]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Mello, J., Boorová, D., Buček, S., Filo, I., Fordinál, K., Havrila, M., Iglárová, Ľ., Kubeš, P., Liščák, P., Maglay, J., Marcin, D., Nagy, A., Potfaj, M., Rakús, M., Rapant, S., Remšík, A., Salaj, J., Siráňová, Z., Teťák, F., Zuberec, J., Zlinská, A. & Žecová, K., 2011: Vysvetlivky ku geologickej mape Stredného Považia 1 : 50 000. [Explanations to the geological map of the Middle Považie region 1 : 50,000]. Bratislava, St. Geol. Inst. D. Štúr, 378 p. [In Slovak with English summary].

Mikuláš, R., Boorová, D. & Holcová, K., 2013: Problematic microscopic trace (?) fossils, Oligocene, Slovakia. *Stratigr. Geol. Correl.,* 21, 3, 300–311.

Nemčok, J., Ďurkovič, T., Gašpariková, V., Snopková, P., Vaňová, M. & Zakovič, M., 1975: Vyhodnotenie štruktúrno-geologického vrtu PU-1 Šambron. [Evaluation of structural-geological well PU-1 Šambron]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Ondrejíčková, A., 1975: Štúdium fauny mäkkýšov zo šlírových sedimentov miocénu. [Study of mollusc fauna from Miocene marly sediments]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Ondrejíčková, A., 1986: Rádioláriové asociácie vrchnej jury a spodnej kriedy. [Upper Jurassic and Lower Cretaceous radiolarian associations]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Ondrejíčková, A., 1990: Rádiolárie triasu a jury Slovenského krasu. [Triassic and Jurassic radiolarians of the Slovak Karst]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Papšová, J., 1975: Taxonomické štúdiá mäkkýšov eocénu Slovenka, čeľaď Pyramidellidae Gray, 1847. [Taxonomic studies of Slovak Eocene molluscs, family Pyramidellidae Gray, 1847]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Papšová, J., 1977: Celkové zhodnotenie makrofaunistických spoločenstiev paleogénu Západných Karpát. [Overall assessment of macrofauna communities of the Palaeogene of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Papšová, J., 1978: Makropaleontologické štúdium Breznianskej kotliny. [Macropalaeontological study of the Breznianska kotlina Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Papšová, J., 1983: Indexové fosílie paleogénu Západných Karpát – mäkkýše. [Index fossils of the Palaeogene of the Western Carpathians – molluscs]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Papšová, J., 1984: Biostratigrafické vyhodnotenie vybraných profilov a lokalít Nízkych Tatier na základe konodontov. [Biostratigraphic evaluation of selected profiles and localities of the Nízke Tatry Mts. based on conodonts]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Pelech, O., Boorová, D., Hók, J. & Rakús, M., 2021: Upper Cretaceous limestone olistoliths in the Rázová Formation (Horné Belice Group), Považský Inovec Mts. (Western Carpathians). *Miner. Slov.,* 53, 1, 37–46 [In Slovak with English abstract].

Pevný, J., 1975: Karnické brachiopódy Západných Karpát. [Carnian brachiopods of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Pevný, J., Papšová, J. & Kochanová, M., 1984: Indexové fosílie triasu Západných Karpát. [Index fossils of the Western Carpathians Triassic]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Planderová, E., 1975: Biostratigrafické členenie neogénu na základe palinologického výskumu. [Biostratigraphic division of the Neogene based on palinological research]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Planderová, E., 1976: Morfológia spór miocénu s aspektom na štúdium mikroštruktúry exín. [Morphology of Miocene spores with an aspect to the study of exins microstructure]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Planderová, E., 1990: Miocene Microflora of Slovak Central Paratethys and its Biostratigraphical Significance. Bratislava, Dionýz Štúr Inst. Geol., 144 p.

Planderová, E., Ondrejíčková, A., Lehotayová, H., Kantorová, V. & Brestenská, E., 1984: Indexové fosílie spodného miocénu Západných Karpát. [Index fossils of the Lower Miocene of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Polák, M. (ed.), Plašienka, D., Kohút, M., Putiš, M., Bezák, V., Maglay, J., Olšavský, M., Havrila, M., Buček, S., Elečko, M., Fordinál, K., Nagy, A., Hraško, Ľ., Németh, Z. Malík, P., Liščák, P., Madarás, J., Slavkay, M., Kubeš, P., Kucharič, Ľ., Boorová, D., Zlinská, A., †Siráňová, Z. & Žecová, K., 2012: Vysvetlivky ku geologickej mape regiónu Malé Karpaty 1 : 50 000. [Explanatory notes to the geological map of the Malé Karpaty region 1 : 50,000]. Bratislava, *St. Geol. Inst. D. Štúr,* 7–287 [In Slovak with English summary].

Potfaj, M., Boorová, D., Fordinál, K. & Pevný, J., 1998: Biostratigrafické vyhodnotenie jurských profilov Západných Karpát. Stratigrafia mladšej jury a staršej kriedy bradla „Žiačik“ na základe mikro a makrofosílií. [Biostratigraphic assessment of Jurassic profiles of the Western Carpathians. Stratigraphy of the younger Jurassic and the Older Cretaceous of the “Žiačik” klippe based on micro and macrofossils]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Rakús, M., 1985: Cephalopodová fauna liasu a álenu z olistolitov račianskej jednotky. [Cephalopod fauna of Lias and Aalenian from the olistoliths of the Rača Unit]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Rakús, M., 1987: Cephalopod Fauna of the Lias and Lower Dogger from olistoliths of the Rača Unit of the Magura Flysch (Locality Lukoveček). *Západ. Karpaty, S*ér. *Paleont*., 12, 7–30.

Rakús, M., 1996: Amonity liasu Západných Karpát – časť sinemúr. [Ammonites of the Lias of the Western Carpathians – part of Sinemurian]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., 1960: Mikrobiostratigrafické vyhodnotenie spodnokriedových vzoriek z Centrálnych Karpát (Strážovská hornatina, Nízke Tatry, Veľká Fatra a Tribeč). [Microbiostratigraphic evaluation of Lower Cretaceous samples from the Central Carpathians (Strážovská hornatina, Nízke Tatry, Veľká Fatra and Tribeč Mts.)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., 1962. Mikrobiostratigrafia spodnej a vrchnej kriedy Západných Karpát (Slovensko). [Microbiostratigraphy of the Lower and Upper Cretaceous of the Western Carpathians (Slovakia)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., 1963: Spodná a stredná krieda jadrových pohorí centrálneho pásma Západných Karpát (M. Karpaty, Strážovská hornatina, V. Fatra, Chočské pohorie a Humenské pohorie). [Lower and Middle Cretaceous of the Core Mountains of the central zone of the Western Carpathians (M. Karpaty, Strážovská hornatina, V. Fatra, Choč Mts. and Humenské vrchy Mts.)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., 1976: Prehodnotenie a spresnenie stratigrafie kriedy Manínskej jednotky. [Reassessment and refinement of the Cretaceous stratigraphy of the Manín Unit]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., 1980: Microbiostratigraphie du Crétacé et du Paléogène de la Tunisie septentrionale et orientale (hypostratotypes tunisiens). Bratislava, Geol. Inst. D. Štúr, 238 p.

Salaj, J., Borza, K. & Samuel, O., 1982: Foraminifery triasu Západných Karpát. [Triassic foraminifers of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J., Borza, K. & Samuel, O., 1983: Triassic Foraminifers of the West Carpathians. Bratislava, Geol. Inst. D. Štúr, 213 p.

Salaj, J. & Samuel, O., 1966: Foraminifera der Westkarpaten – Kreide. Bratislava, Geol. Inst. D. Štúr, 291 p.

Salaj, J. & Samuel, O., 1976: Redefínícia a interregionálna korelácia so štandardnou stratigrafickou škálou cenomanu a turónu na základe foraminifer. [Redefinition and interregional correlation with the standard stratigraphic scale of Cenomanian and Turonian based on foraminifers]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J. & Samuel, O., 1977: Redefinícia a interregionálna korelácia so štandardnou stratigrafickou škálou koniaku a santónu. [Redefining and interregional correlation with the standard stratigraphic scale of the Coniacian and Santonian]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Salaj, J. & Samuel, O., 1978: Taxonómia a fylogenéza triasových foraminifer Západných Karpát (čeľaď Involutinidae). [Taxonomy and phylogeny of Triassic foraminifers of the Western Carpathians (family Involutinidae)]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O., 1966a: Litofaciálny, biostratigrafický a tektonický výskum centrálne karpatského paleogénu. [Lithofacies, biostratigraphic and tectonic research of the Central Carpathian Palaeogene]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O., 1966b: Mikropaleontologické zhodnotenie paleogénu vnútorných kotlín centrálnych Západných Karpát. [Micropalaeontological evaluation of the Palaeogene of the inner basins of the Central Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O., 1983: Indexové fosílie paleogénu Západných Karpát – malé foraminifery. [Palaeogene index fossils of the Western Carpathians – small foraminifers]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O., 1987: Biozonácia paleogénu Západných Karpát na základe planktónových foraminifer a jej paralelizácia so štandardnou biozonálnou schémou. [Biozonation of the Palaeogene of the Western Carpathians based on planktonic foraminifers and its parallelization with the standard biozonal scheme]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O. & Gašpariková, V., 1984: Indexové fosílie Západných Karpát – Krieda. [Index fossils of the Western Carpathians - Cretaceous]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O., Gašpariková, V. & Ondrejíčková, A., 1988: Mikrobiostratigrafická korelácia spodnej a strednej kriedy západnej časti bradlového pásma. [Microbiostratigraphic correlation of the Lower and Middle Cretaceous of the western part of the Klippen Belt]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Samuel, O. & Salaj, J., 1968: Microbiostratigraphy and foraminifera of the Slovak Carpathian Palaeogene. Bratislava, Geol. Inst. D. Štúr, 232 p.

Seneš, J., 1958a: Pholadomya andrusovi nov. sp. zo spodného miocénu južného Slovenska. [Pholadomya andrusovi nov. sp. from the Lower Miocene of southern Slovakia]. *Geol. Práce, Zpr.,* 12, 3–13.

Seneš, J., 1958b: Pectunculus-Sande und Egeren Faunentypus im Tertiär bei Kováčov. Bratislava, *Geol. Práce, Monogr., Sér. 1*, 232 p.

Schmidt, Z., 1975: Elefantoidné chobotnatce slovenských Karpát a nížin. [Elephantoid proboscideans of the Slovak Carpathians and lowlands]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Schmidt, Z., 1976a: Pleistocénna malakofauna spraší Szobskej kotliny Dunaja a bajtavsko--kamenickej depresie dolného Pohronia [Pleistocene malacofauna of loess of the Szobka basin of the Danube and the Bajtava-Kamenice depression of the Lower Pohronie region]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Schmidt, Z., 1976b: Paleontologicko-stratigrafické vyhodnotenie kvartérnych mäkkýšov profilu MH-1 v Malej nad Hronom. [Palaeontological-stratigraphic evaluation of Quaternary molluscs of the MH-1 profile in Malá nad Hronom]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Schmidt, Z., 1977: Malakofauna kvartérnych sedimentov Ipeľskej kotliny. [Malacofauna of the Quaternary sediments of the Ipeľská kotlina Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Schmidt, Z., 1978: Pleistocénna malakofauna spraší Hronskej pahorkatiny. [The Pleistocene malacofauna of loess of the Hronská pahorkatina Uplands]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Snopková, P., 1975: Stanovenie základných peľových spektier z magurskej jednotky východného Slovenska. [Determination of basic pollen spectra from the Magura Unit of eastern Slovakia]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Snopková, P., 1978: Morfológia sporomorf eocénu. [Morphology of Eocene sporomorphs]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Snopková, P., 1983: Indexové fosílie paleogénu Západných Karpát – mikroflóra. [Index fossils of the Palaeogene of the Western Carpathians – microflora]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Snopková, P., 1986: Biostratigrafia paleogénu Ľubovnianskej vrchoviny na základe palinomorf. [Biostratigraphy of the Palaeogene of the Ľubovnianska vrchovina Highlands based on palynomorphs]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Snopková, P. & Samuel, O., 1979: „Hystrichosféry“ terciéru Západných Karpát. [“Hystrichospheres” of the Tertiary of the Western Carpathians]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Šefčík, P., Moravcová, M. & Demko, R., 2019: Klimatostratigrafia, paleoenvironmentálny vývoj a izotopová analýza významných kvartérnych lokalít Slovenskej republiky. [Climatography, palaeoenvironmental development and isotope analysis of important Quaternary localities of the Slovak Republic]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Teťák, F., Kováčik, M., Pešková, I., Nagy, A., Buček, S., Maglay, J., Vlačiky, M., Laurinc, D., Žecová, K., Zlinská, A., Liščák, P., Marcin, D., Žilka, A., Kucharič, Ľ., Gluch, A. & Baláž, P., 2016: Geologická mapa regiónu Biela Orava v mierke 1 : 50 000. [Geological map of the Biela Orava region at a scale of 1 : 50,000]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Vaňová, M., 1983 Indexové fosílie paleogénu Západných Karpát – veľké foraminifery. [Palaeogene index fossils of the Western Carpathians – large foraminifers]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Vaňová, M., 1986: Paleontologická charakteristika niektorých druhov z Jeruzalemského vrchu pri Dobšinej. [Palaeontological characteristics of some species from Jeruzalemský vrch Hill near Dobšiná]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Vass, D., Planderová, E., Kullmanová, A., Zlinská, A. & Karoli, S., 1984: Prognózny ložiskový výskum lignitov vrchného sarmatu a panónu v Choňkovskej depresii. [Prognostic deposit research of lignites of the Upper Sarmatian and Pannonian in the Choňkov depression]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Zlinská, A., 1983: Paleontológia recentných foraminifer „Pacifik-81“. [Palaeontology of recent foraminifers “Pacific-81”]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Zlinská, A., 1997: Biostratigraphy of Sarmatian sediments from the Košická kotlina Depression on the basis of Foraminifers. *Slovak Geol. Mag.,* 3, 4, 285–298.

Zlinská, A., 1998: Mikrobiostratigrafia sedimentov bádenu východoslovenskej panvy na základe foraminifer. [Microbiostratigraphy of Badenian sediments of the East Slovak basin based on foraminifera]. *Zem. Plyn Nafta,* 43, 1, 111–152 [In Slovak].

Zlinská, A., 2004: 5. Paleontologická konferencia. Zborník abstraktov. Bratislava, jún 2004 [5th Palaeontological conference. Collection of abstracts. Bratislava, June 2004]. Bratislava, St. Geol. Inst. D. Štúr, 2004, 118 p. [In Slovak].

Zlinská, A., 2007: 8. paleontologická konferencia. Zborník abstraktov. Bratislava, jún 2007. [8th Palaeontological conference. Collection of abstracts. Bratislava, June 2007. Conferences, Symposia, Seminars, Bratislava, St. Geol. Inst. D. Štúr, 124 p. [In Slovak].

Zlinská, A., 2009: Foraminiferové asociácie z lučenského súvrstvia vrtu FGRk-1 (Rimavská kotlina. [Foraminiferal associations from the Lučenec Formation in borehole FGRk-1 (Rimavská kotlina Basin)]. *Miner. Slov.,* 41, 3, 291–312 [In Slovak with English abstract].

Zlinská, A., 2013: Prvý nález mikrofauny z chrenoveckých vrstiev bielopotockého súvrstvia v Handlovskej kotline. [The first find of a microfauna from the Chrenovec Mb. of the Biely potok Formation in the Handlovská kotlina Basin]. *Acta Geol. Slov.,* 5, 1, 69–82 [In Slovak with English abstract].

Zlinská, A., 2016: Terciérna mikrofauna z hlbokých vrtov v želiezovskej priehlbine (Dunajská panva). [Tertiary microfauna in deep wells of the Želiezovce depression (Danube Basin)]. *Miner. Slov.,* 48, 1, 61–82 [In Slovak with English abstract].

Zlinská, A., 2017: Mikrofaunistické vyhodnotenie paleogénnych sedimentov Dunajskej panvy. [Microfaunistic evaluation of Palaeogene sediments of the Danube Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Zlinská, A. & Fordinál, K., 1989: Výsledky makro a mikropaleontologického štúdia vybraných vzoriek z regiónu Slanské vrchy a Košická kotlina. [Results of macro and micropalaeontological study of selected samples from the region Slanské vrchy Mts. and Košická kotlina Basin]. Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr [In Slovak].

Zlinská, A. & Gross, P., 2013: Vek a litologická charakteristika paleogénnych usadenín Handlovskej kotliny na základe reinterpretácie vrtu FGHn-1 Handlová. [Age and lithology determination in the Handlovská kotlina Basin Palaeogene deposits, based on the FGHn-1 (Handlová) well reinterpretation]. *Acta Geol. Slov.,* 5, 2, 141–153 [In Slovak with English abstract].

21st Slovak-Czech-Polish Paleontological Conference

FIELD TRIP GUIDE

PREFACE

Various groups of fossils of animal and plant origin, which gradually appeared during geological periods, have always been the focus of attention of paleontologists, geologists, students of paleontology, but also amateur researchers. Extinct unique “inhabitants” of the aquatic, especially marine, as well as terrestrial environment constantly attract the attention of people of almost all ages.

Whole generations of paleontologists, respectively geologists and paleontological enthusiasts were collecting macrofossils in the field and, especially in the later period, obtaining microfossils from sediments. They thus created paleontological collections of irreplaceable and incalculable values, which became part of the national wealth of individual countries.

Naturally, there was a need for experts to meet in various scientific fora in order to familiarize themselves with the knowledge gained, to consult each other, to correlate and to expand cross-border cooperation aimed at solving problems of a global character. These meetings significantly contributed to the development of modern concepts of biostratigraphy, paleoecosystems, chronostratigraphy, paleoclimatology, to the determination of global stratotypes. Primary criteria for recognizing chronostratigraphic units and accurate biostratigraphic correlation based on all available aspects of the fossil record have been determined. Individual fragments appeared, which fit into the mosaic of knowledge of the evolution of life on Earth.

One of the traditional events, which brings together not only important experts in the field of paleontology, but all those who incline to fossils, is the Slovak-Czech-Polish paleontological conference (the order of countries in the name of the conference is often changed with regard to the country that organizes it). This year, the twenty-first year of this event was organized on May 23–25 by paleontologists from the Departments of Older and Younger Geological Formations of the State Geological Institute of Dionýz Štúr (SGIDŠ) on the premises of this institution in Bratislava. This happened after a break of almost two years, when this regular meeting was interrupted due to a pandemic situation caused by the coronavirus (Covid-19).

The conferences also included a regular field trips. This year it is focused on two important locations. One of them is represented by the Snežnica section in the Pieniny Klippen Belt, where the Mesozoic sequence of Jurassic and Cretaceous limestones can be studied. The second locality, Cerová-Lieskové, located at the foothills of the Malé Karpaty Mts.

is outcropping Karpatian – ?Badenian calcareous clay and clayey silt *"schlier"* with thin tempestites.

There are still a number of unresolved issues regarding the setting of boundaries of individual stratigraphic levels, which are mainly addressed by working meetings that focus on solving specific problems. Thus the conference will also host regular meeting of the *Polish & Slovak Working Group of the Jurassic System PGS*.

Conference Abstract Books and Field Trip Guides were published for each individual paleontological conference. All previously published collections are available in full on the website: www.geology.sk/21_paleo_conference-history, which was compiled by K. Fekete in cooperation with the members of the organizing committee.

Participants from many countries in Europe and the world have recently become actively involved in Slovak-Czech-Polish paleontological conferences, which earns this event on credit. We believe that the tradition of organizing paleontological conferences will be maintained in the future and will be carried in the same working, creative and friendly atmosphere as before.

The Organizing Committee

BRIEF DESCRIPTION OF GEOLOGY OF WESTERN CARPATHIANS

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INTRODUCTION

The Western Carpathians represent Western part of Carpathian mountain chain – an Alpine fold-and-thrust belt with generally North and Northwest vergence (Andrusov, 1958). Traditionally (e.g. Andrusov et al., 1973; Biely, 1988) divided into the External Western Carpathians (EWECA) dominated by thin-skinned flysch nappes composed of Cretaceous to Paleogene rocks and Internal Western Carpathians (IWECA) composed of thick-skinned basement nappes with complex structure and geologic history. At the boundary of Internal and External Western Carpathians a complicated zone of the Pieniny Klippen Belt (PKB) is developed. In contrast to the Alps, the Western Carpathians are affected by a significant Miocene extension which resulted in formation of the back-arc Miocene Pannonian Basin system, that caused formation of typical horst and graben structure (the Core mountains belt) and extensive Miocene volcanism (Carpathian neovolcanic chain; Kováč, 2000; Pécskay et al., 1995). Also, a presence of large system of fore-arc Paleogene basins (Central Carpathian Paleogene Basin) differs from the Eastern Carpathians.

The boundary of Western Carpathians and the Eastern Alps is largely covered by the Cenozoic sediments of the Vienna and Danube basins. The boundary with the Hungarian Mid-Mountains (Transdanubicum) is represented by the buried Raaba-Hurbanovo-Diosjenő fault zone (Hók et al., 2014) and boundary with Bükkicum is the Darnó fault zone. The eastern boundary of the Internal Western Carpathian units is marked by the Hornád fault system.

The foreland of the Western Carpathians is represented by the Bohemian Massif (in the West) and East European Platform (in the East). The thrusting of the Flysch Belt nappes caused the formation of the Carpathian Foredeep – continuous foreland basin along the entire outer margin of the Carpathian thrust belt in the West continuing to the Alpine Molasse Basin.

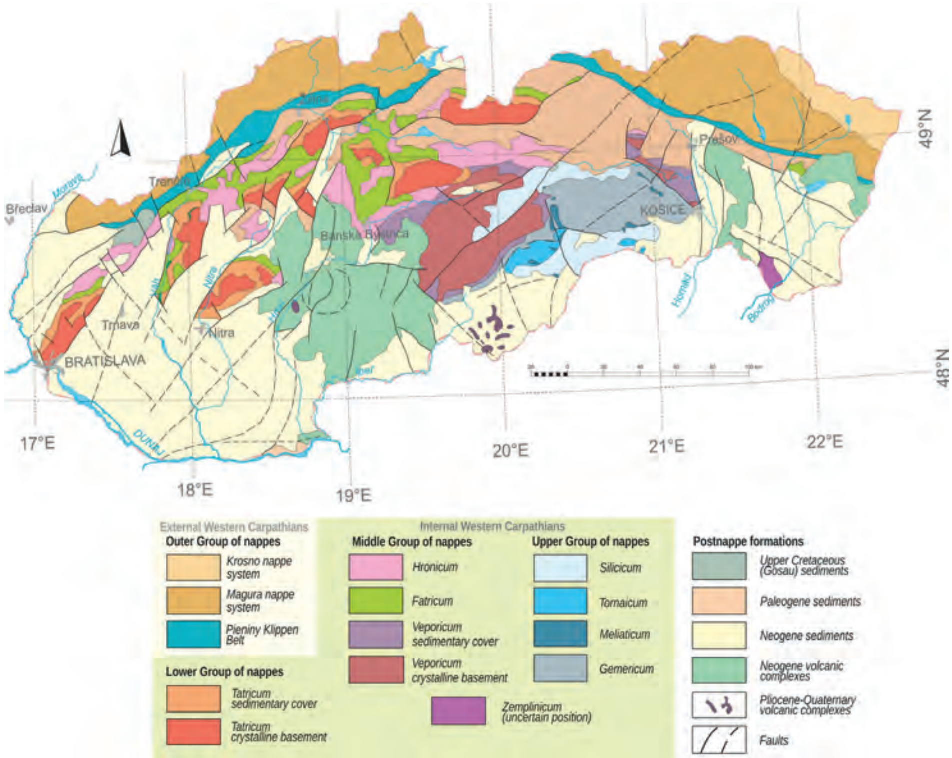

Fig. 1. Schematic tectonic map of the Slovakia (Hók et al., 2019).

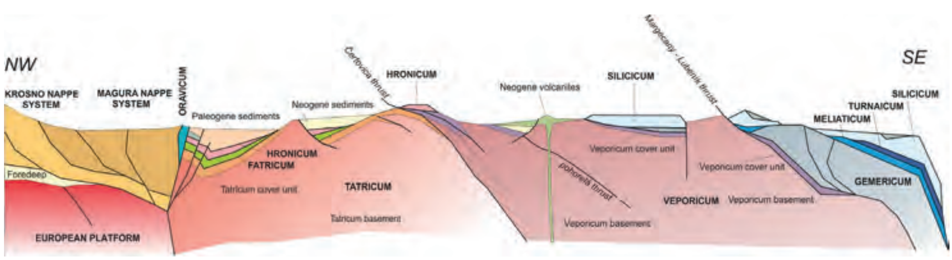

Fig. 2. Schematic cross-section across main tectonic units of Slovak Western Carpathians (Hók et al., 2019). Legend in the Fig. 1.

The External Western Carpathians

The External Western Carpathians (EWECA) comprise of Carpathian Flysch Belt and Pieniny Klippen Belt. Both belts do not contain pre-Mesozoic formations. The EWECA can be characterized as the Cenozoic accretionary wedge, composed of sediments sheared of the European plate.

Carpathian Flysch Belt

The Flysch Belt of EWECA represents massive accretionary wedge in the frontal (outer) part of the Western Carpathian orogen. The imbricated rootless nappe stack composed of a fold and thrust belt of the Magura and Silesian nappe system and other more external units is thrust towards the northwest and northeast over the inclined ramp of the Bohemian Massif and European Platform Foredeep (Hók et al., 2019). The Biele Karpaty and Krynica units were additionally backthrust to the south over the Pieniny Klippen Belt (Pešková et al., 2012; Teťák, 2021). The Magura and Silesian nappes are formed by the Upper Cretaceous and Paleogene formations of typical flysch formed by alternating layers of claystones and sandstones to conglomerates and deposited in the deep-water environment by the gravity flows. The sedimentary sequences of Flysch Belt units contain an extensive record of paleogeography of several basins and ridges. The outermost (most external) part of EWECA represent the Marginal nappe system occurring only on the northwestern edge of Flysch Belt. It is formed by Pouzdřany-Ždánice-Waschberg Nappe representing the allochthonous nappe thrusted over the Bohemian Massif margin. The sediments of the Carpathian Foredeep are generally situated below the Krosno and also Magura nappe systems. The Marginal nappe system represents autochthonous Miocene-Pliocene sedimentary cover of the Bohemian Massif as well as European Platform (Hók et al., 2019; Teťák et al., 2019).

The former EWECA Cretaceous to Paleogene age deep-sea flysch basins were situated in the area between the IWECA block and the European Platform. The basins were bordered by continental crust ridges which delivered a clastic material to several basins (Książkiewicz, 1962; 1965; Teťák et al., 2019). Similarly, as the area of the Carpathian Foredeep, also the Magura Basin was connected to the west to the flysch foreland of the Eastern Alps (Rhenodanubian Flysch) and similarly to the north and east to the sedimentation area of the more external units at various periods.

The deposits of the **Magura nappe system** were deposited in the Magura Basin, which originated as a typical deep-marine foreland basin system at the head of an advancing orogenic belt formed by units of the Inner Western Carpathians. The preserved deposits are mostly of the Upper Cretaceous and Paleogene age (Cieszkowski, 1992; Lexa et al., 2000; Picha et al., 2006; Kaczmarek et al., 2016). The Magura Nappe is related to the Rhenodanubian Flysch, which is not entirely clear because the contact of these units lies beneath the Neogene infill of the Vienna Basin (Kröll et al., 1993). Five tectono-lithofacies units of the Magura Nappe are present. From the innermost they are the Biele Karpaty, Krynica (former Oravská Magura), Bystrica, Rača and Siary units. Dozens of lithostratigraphic units have been determined by the combination of lithotypes and lithofacies deposited in the deep-sea environment on the bottom formed probably by oceanic or attenuated continental crust of the Magura Basin or on its slope.

The deposits of the Siary and Biele Karpaty units represent marginal parts of the Magura Basin formed by deposits of marginal coarse-clastic wedge and olistoliths (Soláň Fm, Mutne Mb., Skawce Mb.), larger fans (Javorina Mb. and Riečky type sandstone) and smaller fans (Drietomica and Chabová mbs.). The Krynica, Bystrica and Rača units include the most characteristic facies for the Magura Nappe the thin-bedded facies accompanied by variegated green and red claystones which deposited in the internal part of the Magura Basin. Hundreds of meters thick complexes of quartz-carbonate sandstones (most of the Biele Karpaty Unit), greywacke Magura type sandstones (most of the Krynica Unit and Kýčera Mb.), quartzy glauconite sandstones (Vsetín and Bystrica mbs) represent large sandstone-rich fans (Teťák et al., 2019). The sedimentation finally took place in smaller piggy-back sub-basins (Oligocene Malcov Fm).

The underlying **Krosno nappe system** includes from inner to outer as follows: Dukla (Grybów, Fore-Magura), Silesian, Sub-Silesian and Skole nappes (Lexa et al., 2000; Hók et al., 2019). The Dukla Nappe reaches the Polish-Slovak-Ukrainian border. Its sedimentation area was initially associated with the Magura Basin. Younger deposits have affinity rather with the Silesian Nappe. To the west, Dukla Nappe passes into Grybów and Fore-Magura nappes, which underlie the Magura Nappe and crop out sporadically, e. g. in the Smilno tectonic window. The most characteristic for the Krosno nappe system are the menilite shales or Menilite Formation, composed of brown claystones with bodies of sandstones and black cherts with diatoms tests deposited during the late Eocene to early Oligocene. Another very characteristic lithostratigraphic unit is the Sub-Menilite Fm of Eocene age, being composed of variegated (red, green and grey) claystones and sandstones. The Ciśna and Istebna fms represent the thick sandstone complexes.

The Pieniny Klippen Belt

The Pieniny Klippen Belt (PKB) represents relatively narrow zone at the EWECA and IWECA contact with structure distinctly differing from neighboring units. The structural position of the PKB was originally above the EWECA flysch nappes and below the IWECA units. It is characterized by competent Jurassic to Lower Cretaceous limestone “klippen” usually surrounded by the less competent Upper Cretaceous flysch formations. The “klippen” are often considered as loose blocks in Upper Cretaceous matrix and whole belt as a suture-related mélange, olistostrome or megabreccia (Plašienka, 2018 for review). The structure of the belt is very complex. It was affected by several phases of shortening and transpression to transtension with laterally varying intensity in particular segments. Due to long-term detailed research of stratigraphy more than 15 more or less different sedimentary successions (or units, Mišík, 1997) and far more lithostratigraphic units (e. g. Birkenmajer, 1977; Andrusov & Samuel, 1971) were introduced in the area which brought considerable complexity as well as terminological problems. However, it can be stated that the PKB consists of principally 2 types of sedimentary successions or units. The first are the so called Oravic units (formerly Pienid, related to the paleogeographically distinct zone different from IWECA in the South and EWECA in the North). The second are the Non-Oravic units, whose character of the sedimentary sequence or structural position suggests origin in the IWECA. The Oravic units are divided into the Kysuca-Pieniny Unit with deep water Jurassic-Cretaceous sedimentary sequence [Jurassic “Fleckenmergel” and radiolarites, Cretaceous pelagic Pieniny (Biancone) type limestones, marls and transition into syn-orogenic Albian-Maastrichtian flysch]; and Czorstyn Unit with shallow water Jurassic-Cretaceous sequence [Jurassic crinoidal and nodular (Ammonitico Rosso) limestones and, signs of carstification and Cretaceous oceanic red bed sediments, e. g. Púchov Fm]. Transitional Oravic successions (e. g. Pruské, Niedzica, Streženice, Nižná units) bare different signs of mixed shallow and deep-water origin. The prevailing view is that Czorstyn Unit was situated north of the Kysuca Unit (Andrusov, 1958, 1968, in present day coordinates). The Non-Oravic units represent wide range of different units. The Manín, Drietoma, Haligovce and Klape units are most often included here. The Manín (and Haligovce) Unit contains shallow water Urgonian type limestones and probably represents frontal elements of Fatricum or Tatricum. The Drietoma Unit is the only sedimentary succession of the Pieniny Klippen Belt characterized by presence of Upper Triassic sediments, it is also probably part of frontal elements of Fatricum or Tatricum. The Klape Unit is characterized by the presence of thick complex of Albian-Turonian flysch sediments with common exotic conglomerates (Marschalko, 1986).

The Internal Western Carpathians

The Internal Western Carpathians (IWECA) represents Cretaceous thick-skinned thrust belt composed of three principal basement-cover nappes Gemericum, Veporicum and Tatricum thrust on each other from the South to North (in present day coordinates). The Western Carpathian nappe stack south/internally of the Pieniny Klippen Belt represent an equivalent of the Adria-derived far traveled Austroalpine nappes of Alps (Schmid et al., 2020). Especially in terms of the later Cenozoic evolution the IWECA is commonly referred to as the ALCAPA megaunit (e.g. Csontos & Vőrős, 2004).

The IWECA nappe stack also includes Fatricum and Hronicum cover/thin-skinned nappes mostly present above the Tatricum and Veporicum, and Meliata Ocean derived nappes of Meliaticum, Turnaicum and Silicicum overlying the Gemericum.

Tatricum

Tatricum is structurally the lowest tectonic unit of the Internal Western Carpathians. Formed by the Paleozoic crystalline basement rocks and an autochthonous (mostly) Mesozoic sedimentary cover exposed in the region of the core mountains south of the Pieniny Klippen Belt and in the footwall of Veporicum basement nappe. The contact of Tatricum and Veporicum is called the Čertovica shear zone. At the same time Tatricum is overlain by the Fatricum and Hronicum cover nappes.

On seismic sections (e.g. 2T) it has a tabular shape slightly thinning towards the south (Bezák et al., 1993). Tatricum is usually correlated with the Lower Austroalpine units of the Eastern Alps.

The crystalline basement is represented mainly by gneisses, amphibolites, mica schists and granitoids (I- and S-types) formed during the Variscan orogeny (mostly Carboniferous). The Tatricum represented the internal zone of the Variscan orogen. The sedimentary cover is represented by the Upper Paleozoic to Lower Cretaceous sediments.

The oldest sediments of the Tatricum are represented by the Pennsylvanian (found only in the Považský Inovec Mts.) and Permian clastics, locally preserved in particular regions (Malé Karpaty, Považský Inovec, Malá Fatra, Nízke Tatry Mts.). The Lower Triassic Lúžňa Formation, often overlying deeply eroded crystalline basement rocks, marks the transition from the continental (quartz sandstones) to shallow water carbonate ramp environment (calcareous shales, limestones). The Middle Triassic to Carnian carbonate ramp to platform (dark Gutenstein limestones, Ramsau and Main

Dolomite) was interrupted in the Norian by the lagoonal, locally probably up to continental Karpathian Keuper sediments. Rhaetian sediments were mostly eroded during Early Jurassic rifting. Their remnants are known only from the Tatry Mts. (continental siliciclastic sediments with dinosaur tracks) and Strážovské vrchy Mts. (shallow marine carbonates). During the Jurassic the Western Carpathian region was significantly affected by the rifting. Extension resulted in formation of the subsiding basins and elevated ridges (Maheľ, 1984; Plašienka, 1999, 2003). In the Tatric domain, Jurassic lithofacies are divided into the shallow-water Tatra type (mainly crinoidal and nodular Adnet type limestones) and the deep-water Fatra type (radiolarian limestones, Allgäu Fm spotted marl and limestone facies). The Upper Jurassic to Lower Cretaceous sediments are mostly uniformly calpionellid and nannoconid often cherty limestones (Lučivná Formation). During the Early Cretaceous several areas were however again affected by the emergence and deposition of shallow water platform carbonates (or their basinal redeposits) (e.g. Wysoka Turnia Fm; Lefeld et al., 1985). The sedimentation in the Tatricum was terminated in the Cenomanian–Turonian. The syn-orogenic clastics (flysch) of the Poruba Formation are often accompanied by the exotic conglomerates. Rarely the Upper Cretaceous (Coniacian–Maastrichtian) flysch type sediments with olistoliths are present (Horné Belice Group in the Považský Inovec Mts.).

Fatricum

The Fatricum (sometimes referred as the Lower Sub-Tatricum or Krížna Nappe) is more or less flat lying cover nappe occurring above the Tatricum basement-cover thrust sheets and bellow the Hronicum in the Core Mountains Belt. It is rooted in the Northern Veporic Veľký bok Unit. Composed of Triassic to Lower Cretaceous succession with similar character as the aforementioned Tatric sedimentary cover (e. g. Andrusov, 1959). The basal décollement is usually located in the shaly Lower Triassic sediments or in the Norian Carpathian Keuper (Prokešová et al., 2012). Based on the character of the Jurassic sediments two units are recognized: the shallow water Vysoká Unit and deep water Zliechov Unit, which is also the most widespread (Maheľ, 1983; Pečeňa & Vojtko, 2011).

In contrast to the Tatric sedimentary cover, the Fatricum has usually thick Carpathian Keuper shales; well preserved Rhaetian shallow water carbonates (Fatra Fm) and typically well preserved and thicker Jurassic to Early Cretaceous age deep marine deposits (spotted marls and limestones of the Allagäu Fm, radiolarian limestones and radiolarites of Ždiar Fm, nodular limestones of the Jasenina Fm, calpionellid and nannoconid Mraznica Fm, dark shales alternating with organodetritic limestones of the Párnica Fm). The sedimentary record was terminated in the Albian (Poruba Fm). The nappe was emplaced during the Tatric-Veporic collision in the Albian to Turonian (Prokešová et al., 2012).

Hronicum

The Hronicum (formerly the Choč Nappe or Higher Sub-Tatric Nappe) represents structurally highest cover nappe in the Core Mountains Belt overlying the Fatricum; and marginally also occurring above the Veporicum. It differs from the underlying Fatricum and Tatricum by the different type of the Triassic succession with affinity to the Upper Austroalpine units (Wetterstein and Dachstein facies). It contains predominantly Middle to Upper Triassic carbonates (Gutenstein and Wetterstein limestones and dolomites, Reifling Fm, Main Dolomite) as well as the Lunz Beds reaching larger thicknesses compared with Fatricum or Tatricum. The Jurassic to Lower Cretaceous rocks are preserved only locally and in small thickness (e.g. the Rohatá skala group in the Strážovské vrchy Mts.). The Hronicum is divided based on the character of the Middle Triassic sediments and their position into the Čierny Váh and Mojtín-Harmanec carbonate platforms and Čierny Váh and Dobrá Voda basins (Havrila, 2011). These sedimentary successions were individualized during the Cretaceous thrusting and can form three individual thrust sheets or nappes (Kováč & Havrila, 1998).

Veporicum

The Veporicum is basement thrust sheet overlying the Tatricum in the NW (contact seen at the Čertovica shear zone). In the SE it forms a footwall of the Gemericum. Their contact is known as the Lubeník and Margecany shear zones. Apart of large area exposed in the Veporské vrchy (Veporic core complex; Janák et al., 2001), it forms as well the pre-Cenozoic basement of the Central Slovakia Neogene volcanic field, the basement of the Central Carpathian Paleogene Basin and the basement of the Danube Basin Miocene sedimentary fill (SW Slovakia and N Hungary).

It is composed mainly of the crystalline basement rocks and the Upper Paleozoic-Mesozoic sedimentary cover affected by the Alpine metamorphic overprint. The basement rocks are similarly as in the Tatricum represented by the high grade Variscan metamorphic rocks and granitoids. Crystalline basement contains metamorphic rocks of various degrees and ages (mica-schists, para- and orthogneisses, amphibolites, migmatites, eclogite relicts and weakly metamorphosed phyllites, serpentinites and magnesites) as well as granitoids (e.g. Vepor and Kráľova hoľa, Rimava or Sihla types). Locally presence of Late Cretaceous Rochovce granite near the contact with the overlying Gemericum was proven (Hraško et al., 1999). It recorded a complex polymetamorphic Variscan and Alpine evolution. The phenomenon of superposition of granites (Kráľova hoľa Complex) above the mica-schists (Hron Complex), as a result of Alpine thrusting, can be often observed (e.g. Klinec, 1966). Vertically and horizontally (in the map view), the Veporicum is traditionally divided into several zones (from S to N: Kohút, Kráľova hoľa, Kraklová and Ľubietová zones; Zoubek, 1957) separated by NE-SW faults (e.g. Muráň fault, Pohorelá shear zone).

In the northern part, the sedimentary cover is known as the Veľký bok Unit. It shows common sedimentary character and evolution with the Fatricum, as the Veľký bok Unit is considered the root zone of the Fatric nappe system. The southern portion of the Veporicum (south of the Pohorelá shear zone) is characterized by the different sedimentary cover – the so called Föderata Unit, with elements shared with the Hronicum (Straka, 1980; Vojtko et al., 2000).

Gemericum

The Gemericum is thick-skinned tectonic unit overlying the Veporicum (Bajaník et al., 1984; Grecula et al., 2009). The Veporic-Gemeric contact zone is known as the Lubeník-Margecany Shear zone. Traditionally it is divided into the Northern and Southern Gemericum. It builds substantial part of the Spišsko-gemerské rudhorie Mts., Volovské vrchy Mts. and the so called West Gemeric spur (area of Jelšava and Poltár). In the south it is underthrust below the Meliaticum mélange and Turnaicum and Silicicum nappes. The Gemericum consists of relatively thin (5 – 10 km) Variscan basement with the Upper Paleozoic-Mesozoic sedimentary cover. In the surface it is mainly composed of low-grade metamorphic rocks, Lower Paleozoic phyllites, metarhyolites and metabasalts. Substantial part, forming the basement of the South Gemericum is represented by the Gelnica Group (Ivanička et al., 1989). Gneisses and amphibolites are present in lesser extent. The Lower Paleozoic complexes are intruded by Permian granitoids, which do not form larger bodies on the surface, however, form a substantial part of the body of the Gemericum in the subsurface (Šefara et al., 2017). Carboniferous-Triassic autochthonous sedimentary cover is composed of terrigenous clastics and carbonates, occurring mainly in the area of the Northern Gemericum.

Meliaticum and Turnaicum

The Jurassic ophiolite bearing mélange of the Meliaticum is located between the Gemericum and the sole of Turnaicum and Silicicum in the areas of Slovenský kras Karst and Slovenský raj Karst (Meliata, Jelšava, Dobšiná, Honce, Hačava, Jaklovce, Dobšinská ľadová jaskyňa and other localities). It is traditionally divided into unmetamorphosed part, the Jaklovce Unit (Mock et al., 1998), and HP-LT metamorphosed blueschist bearing Bôrka Nappe (Mello et al., 1998). The main part of the Jaklovce Unit is represented by the Meliata Fm – the Lower to Middle Jurassic shales, sandstones and radiolarites with blocks of basalts, serpentinites and radiolarites. It represents exhumed subduction-accretion complex of the Triassic-Jurassic Meliata ocean (or back-arc basin, e.g. Ivan, 2008).

A transitional unit between the metamorphosed Meliatic fragments and overlying unmetamorphosed Silicicum is designated as Turnaicum (e.g. Lačný et al., 2016). This unit is present as well in the Hungarian territory (Kövér et al., 2009). It contains Carboniferous to Jurassic sediments affected by the low-grade regional metamorphism.

Silicicum

The structurally highest tectonic unit of the Internal Western Carpathians is the Silicicum (Mello, 1979), which is overlying various tectonic units (Meliaticum, Turnaicum as well as Gemericum and Veporicum, locally possibly Hronicum), It is mostly present in the karst areas of central and southeastern Slovakia (Muránska planina, Slovenský kras, Slovenský raj) and continues to the Hungary (Aggteleki-karszt). Silicicum forms erosional remnants of larger nappe now dismembered into separate Silica-Aggtelek, Stratená, Vernár, Muráň and Drienok nappes. It is formed by the Permian to Jurassic mostly carbonate formations with characteristic thick Oberostalpin type Wetterstein facies (Mello et al., 1997). The youngest sediments of Silicicum are Upper Jurassic (Rakús & Sýkora, 2001) and their deposition was followed by the nappe emplacement related to the subduction of the Meliata ocean. Locally also the Gosau type Upper Cretaceous sediments were preserved (e.g. Šumiac, Miglinc Valley, area of the Dobšinská ľadová jaskyňa).

Zemplinicum

Rocks cropping from below the Cenozoic sediments and volcanites in the Zemplínske vrchy Mts. have problematic tectonic affiliation. Some authors consider it part of the Veporicum, others as a separate unit

(Slávik, 1976; Plašienka & Soták, 2015). Zemplinicum contains Variscan crystalline complexes, Upper Paleozoic-Mesozoic sedimentary cover with Carboniferous coal seams and probably also an Upper Cretaceous sediments.

Upper Cretaceous-Paleogene sediments

The Internal Western Carpathian nappe stack was formed during the mid-Cretaceous. During the Late Cretaceous ("Senonian") numerous sedimentary basins were formed atop of various tectonic units. The Ostriež, Brezová and Myjava-Hričov groups were deposited atop of the Hronicum (Mello et al., 2011; Teťák et al., 2015; Soták et al., 2021). Other occurrences are known also from the Tatricum (Horné Belice Group, Hubina Formation; Pelech et al., 2017) and Silicicum (e. g. Mišík, 1978). They partly represent piggyback basins, and their subsidence later continued due to collapse of the orogenic wedge (e.g. Plašienka & Soták, 2015).

Other phase of large-scale subsidence affected the Western Carpathians during the Paleogene. Particularly the Eocene-Oligocene Central Carpathian Paleogene Basin (CCPB, or the Podtatranská Group) was formed atop of the dismembered nappe stack in the central Slovakia (Gross, 2008; Soták et al., 2001; Kováč et al., 2016). The deposition started with shallow water clastics and nummulitic limestones and was later replaced by the deep water turbiditic sediments. The sediments of the CCPB were diachronous. Transgression was older in the West and younger in the East. Other type of Paleogene sediments known as the Štúrovo or South Slovak Paleogene Basin are located south of Raaba-Hurbanovo fault zone and are part of the Hungarian-Slovenian Paleogene Basin (e. g. Haas et al., 2012).

Neogene to Quaternary basins and volcanic formations

Since the Oligocene face of the Western Carpathian mountain chain was gradually changing. The area of IWECA was influenced by push of Apulian plate in the hinterland and subduction roll back of at least partly oceanic crust south of European plate in the foreland. At the same time the Western Carpathians were affected by the lateral escape to the north-east and partly also the counter-clockwise rotation (Nemčok et al., 1998; Fodor et al., 1999; Márton et al., 2016; Kováč et al., 2017). These processes resulted in new phase of extension. Gradually the characteristic Core mountains Belt with basin and range type morphology evolved. Since the Middle Miocene an extensive volcanism affected central and eastern Slovakia.

Miocene sediments unconformably and transgressively overlap mostly Mesozoic nappe stack, or pre-existing Upper Cretaceous and Paleogene basins. The largest Neogene to Quaternary basins are (form West to East) the Vienna and Pannonian Basin system (including Danube, south Slovak basins Buda, Fiľakovo, Novohrad-Nógrád basins and East Slovak (or Trans-Carpathian) Basin). Other smaller basins include Trenčianska kotlina, Ilavská kotlina, Hornonitrianska kotlina, Žiarska kotlina, Turčianska kotlina and Orava Basin (e. g. Vass, 2002).

The sedimentation started during the Eggenburgian as a wedge top basin in the Vienna Basin, northern portion of the Danube Basin and in the Trenčianska kotlina, Ilavská kotlina and Hornonitrianska kotlina basins, that were filled by marine clastic sediments (e.g. Čausa, Dobrá Voda Fms). Other Lower Miocene marine sediments are cropping out in the Fiľakovo and Novohrad-Nógrád basins which structurally represent the youngest part of the Hungarian Paleogene Basin. The evolution of the Pannonian Basin *sensu stricto* started since Middle Miocene (Šujan et al., 2021). Marine sedimentation (Bajtava, Špačince, Pozba and Báhoň Fms) gradually changed since the Sarmatian into brackish (Vráble Fm) and later during the Pannonian into lacustrine and deltaic sedimentation (Ivanka and Beladice Fms). Later on fluvial (alluvial) and continental conditions prevailed (Volkovce Fm).

The Vienna Basin was initially developed as the wedge top basin (e.g. Brezová, Chropov, Winterberg Mb. and Lužica Fms). In the Karpatian the pull-apart basin evolved (deltaic Aderklaa Fm and basinal Lakšáry Fm). In the Badenian and Sarmatian change to extensional back-arc basin with gradual change from neritic to deltaic sedimentation occurred. Since the Pannonian shallow brakish to deltaic and later lacustrine and continental conditions dominated (Kováč, 2000; Vass, 2002).

The East Slovak Basin represents another polygenetic basin which partly linked to youngest part of the Central Carpathian Basin (e. g. Egerian sediments). In the Karpatian–early Badenian it evolved as pull-apart basin (e. g. lagoonal Soľná baňa Fm) and later changed to the extensional back-arc basin with gradual shift from neritic to deltaic and limnic sedimentation (Kováč, 2000; Vass, 2002). The basin was during the Middle Miocene affected by volcanism in the nearby Vihorlat and Slanské vrchy Mts.

Another distinctive feature of the Western Carpathians, apart of intensive Pannonian Basin subsidence during the Miocene, is the largescale Cenozoic volcanism which occurred in several phases and resulted in formation of Central Slovak and East Slovak volcanic provinces with numerous volcanic centres. Cenozoic volcanism of the Carpathian arc was related to subduction of former External Western Carpathians basement and back-arc extension of the Pannonian Basin system (Pécskay et al., 1995; Lexa & Konečný, 1998). Four stages of the volcanic activity can be characterized within the Slovak territory. The oldest Early Miocene areal type silicic volcanism (dacites to rhyolites), mostly tuffs and ignimbrites, located in the southern and eastern Slovakia.

The second phases of volcanism is represented by intermediate areal-type calc-alkaline volcanites (mostly andesites) of Badenian and Sarmatian age forming the Central Slovak Neovolcanic Field (e.g. Štiavnica stratovolcano). Locally also apical parts of the Badenian-Sarmatian granodiorite intrusion is exposed in the of Hodruša and Banská Štiavnica (Konečný et al., 1998a, b). The third phase is represented by the intermediate calc-alkaline arc type volcanites (mostly andesites or basaltic andesites) in the eastern Slovakia. The final fourth phase is represented by Pliocene to Quaternary alkali basalts occurring mostly in Southern Slovakia.

The shape of present day-relief was gradually formed since the Pliocene. The ongoing orogenic collapse resulted in continuous subsidence of particular regions and at the same time uplift of some mountains, which still continues up today. The Quaternary sediments cover up to 2/3 of the Slovak territory. Their thickness and character strongly vary depending on the character of the basement rocks, topography and weather conditions (Maglay et al., 2009). Thick accumulations of Quaternary fluvial sediments (up to 500 m) are located in the Gabčíkovo Depression of the Danube Basin. The Quaternary was a period of large climate oscillations. Thick accumulation of glacial and glacifluvial sediments occur in the Tatry Mts. Loess, sometimes in considerable thickness accumulated in the valleys of larger rivers, particularly in the area of Trnavská pahorkatina Upland (Maglay et al., 2011). The eolian sands were deposited in the Záhorská nížina Lowland, where the highest dunes reach tens of meters (Fordinál et al., 2012). Travertines and some tufas often follow the tectonically active faults or the areas with higher heat flow with natural thermal springs (Pivko & Vojtko, 2021).

References:

Andrusov, D., 1958: Geológia Československých Karpát I. *Bratislava, Veda, Vyd. Slov. Akad. Vied,* 303 pp.

Andrusov, D., 1959: Geológia Československých Karpát II. *Bratislava, Veda, Vyd. Slov. Akad. Vied,* 375 pp.

Andrusov, D., 1968: Grundriss der Tektonik der Nordlichen Karpaten. *Bratislava, Veda, Vyd. Slov. Akad. Vied.,* 189 pp.

Andrusov, D. a Samuel, O., 1971: Najnovšie stratigrafické poznatky z bradlového pásma Považia. Dielčia záverečná správa. *Manuskript.* Bratislava, archív Št. Geol. Úst. D. Štúra (arch. č. 26777), 86 s.

Andrusov, D., Bystrický, J. & Fusán, O., 1973: Outline of the Structure of the West Carpathians. X. Congres of Carpathian-Balkan Association. *Bratislava, Geol. Úst. D. Štúra,* 1 – 44.

Bajaník, Š. (ed.), Ivanička, J., Mello, J., Reichwalder, P., Pristaš, J., Snopko, L., Vozár, J. & Vozárová, A., 1984: Geologická mapa Slovenského rudohoria – východná časť 1 : 50 000. *Bratislava, Geol. Úst. D. Štúra*.

Bezák, V., Hók, J., Kováč, P. & Madarás, J., 1993: Možnosti tektonickej interpretácie seizmického profilu 2T. In: Rakús, M. & Vozár, J. (eds.): Geodynamický model a hlbinná stavba Západných Karpát. Konferencie, sympóziá, semináre. *Bratislava, Geol. Úst. D. Štúra*, 287 – 290.

Biely, A., 1988: The geological structure of the West Carpathians. In: Rakús, M., Dercourt, J. & Nairn, A. E. M. (eds.): Evolution of the northen margin of Tethys. Vol. II. *Mém. Soc. Géol. France, Nouv. Sér. (Paris),* 154, II, 51 – 57.

Birkenmajer, K., 1977: Jurrassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carphatians, Poland. *Stud. geol. pol.,* 45, 101 – 121.

Cieszkowski, M., 1992: Marine Miocene deposits near Nowy Targ, Magura Nappe, Flysch Carpathians (South Poland). *Geol. Carpath.,* 43, 339 – 346.

Csontos, L. & Vőrős, A., 2004: Mesozoic plate tectonic reconstruction of the Carpathian region. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 210, 1 – 56.

Fodor, L., Csontos, L., Bada, G., Györfi, I. & Benkovics, L., 1999: Tertiary tectonic evolution of the Pannonian Basin system and neighbouring orogens: a new synthesis of palaeostress data. In: Durand, B., Jolivet, L., Horváth, F., Séranne, M. (eds): The Mediterranean Basins: Tertiary Extension within the Alpine Orogen. *Geol. Soc., London, Spec. Publ.,* 156, 295 – 334.

Fordinál, K. (ed.), Maglay, J., Elečko, M., Nagy, A., Moravcová, M., Vlačiky, M., Kohút, M., Németh, Z., Bezák, V., Polák, M., Plašienka, D., Olšavský, M., Buček, S., Havrila, M., Hók, J., Pešková, I., Kucharič, Ľ., Kubeš, P., Malík, P., Baláž, P., Liščák, P., Madarás, J., Šefčík, P., Baráth, I., Boorová, D., Uher, P., Zlinská, A. a Žecová, K., 2012: Vysvetlivky ku geologickej mape Záhorskej nížiny 1 : 50 000. *Bratislava, Št. Geol. Úst. D. Štúra,* 7 – 232.

Grecula, P. (ed.), Kobulský, J., Gazdačko, Ľ., Németh, Z., Hraško, Ľ., Novotný, L. & Maglay, J., 2009: Geologická mapa Spišsko-gemerského rudohoria 1 : 50 000. *Bratislava, MŽP SR – Št. Geol. Úst. D. Štúra.*

Gross, P., 2008: Litostratigrafia Západných Karpát: Paleogén – podtatranská skupina. *Bratislava, Št. Geol. Úst. D. Štúra,* 78 pp.

Haas, J. (ed.), Hamor, G., Jambor, A., Kovacs, S., Nagymarosy, A. & Szederkenyi, T., 2012: Geology of Hungary. *Berlin – Heidelberg, Springer,* 224 pp.

Havrila, M., 2011: Hronikum: paleogeografia a stratigrafia (vrchný pelsón – tuval), štrukturalizácia a stavba. *Geol. Práce, Spr.,* 117, 7 – 103.

Hók, J., Šujan, M. & Šipka, F., 2014: Tektonické členenie Západných Karpát – prehľad názorov a nový prístup. *Acta Geol. Slov.,* 6, 2, 135 – 143.

Hók, J., Pelech, O., Teťák, F., Németh, Z. & Nagy, A., 2019: Outline of the geology of Slovakia (W. Carpathians). *Miner. Slov.,* 51, 31 – 60.

Hraško, Ľ., Határ, J., Huhma, H., Mäntäri, I., Michalko, J. & Vaasjoki, M., 1999: U/Pb zircon dating of the Upper Cretaceous granite (Rochovce type). *Krystalinikum,* 25, 163 – 171.

Ivan, P., 2008: Relics of the Meliata ocean crust: geodynamic implication of mineralogical, petrological and geochemical proxies. *Geol. Carpath.,* 53, 4, 245 – 256.

Ivanička, J., Snopko, L., Snopková, P. & Vozárová, A., 1989: Gelnica Group – Lower unit of Spišsko-Gemerské Rudohorie Mts. (Western Carpathians) Early Paleozoic. *Geol. Zbor. – Geol. Capath.,* 40, 4, 483 – 501.

Janák, M., Plašienka, D., Frey, M., Cosca, M., Schmidt, S. T., Lupták, B. & Méres, Š., 2001: Cretaceous evolution of a metamorphic core complex, the Veporic unit, Western Carpathians (Slovakia): P–T conditions and in situ ^{40}Ar/^{39}Ar UV laser probe dating of metapelites. *J. Metamorph. Geol.,* 19, 197 – 216.

Kaczmarek, A., Oszczypko-Clowes, M. & Cieszkowski, M., 2016: Early Miocene age of Stare Bystre Formation (Magura Nappe, Outer Carpathians, Poland) indicated by the calcareous nannoplankton. *Geol. Quart.,* 60, 341 – 354.

Klinec, A., 1966: K problémom stavby a vzniku veporského kryštalinika. *Zbor geol. Vied, Západ. Karpaty,* 7 – 27.

Konečný, V. (ed.), Lexa, J., Halouzka, R., Dublan, L., Šimon, L., Stolár, M., Nagy, A., Polák, M., Vozár, J., Havrila, M. & Pristaš, J., 1998a: Geologická mapa Štiavnických vrchov a Pohronského Inovca 1 : 50 000. *Bratislava, MŽP SR – GS SR.*

Konečný, V. (ed.), Lexa, J., Halouzka, R., Hók, J., Vozár, J., Dublan, L., Nagy, A., Šimon, L., Havrila, M., Ivanička, J., Hojstričová, V., Mihaliková, A., Vozárová, A., Konečný, P., Kováčiková, M., Filo, M., Marcin, D., Klukanová, A., Liščák, P. & Žáková, E., 1998b: Vysvetlivky ku geologickej mape Štavnických vrchov a Pohronského Inovca (štiavnický stratovulkán) 1 : 50 000. *Bratislava, GS SR, Vyd. D. Štúra,* 473 pp.

Kováč, M., 2000: Geodynamický, paleografický a štruktúrny vývoj karpatsko-panónskeho regiónu v miocéne: Nový pohľad na neogénne panvy Slovenska. *Bratislava, Veda, Vyd. Slov. Akad. Vied,* 202 pp.

Kováč, M., Plašienka, D., Soták, J., Vojtko, R., Oszczypko, N., Less, G., Ćosović, V., Fügenschuh, B. & Králiková, S., 2016. Paleogene palaeogeography and basin evolution of the Western Carpathians, Northern Pannonian domain and adjoining areas. *Global Planet. Chang*, 140, 9 – 27. https://doi.org/10.1016/j.gloplacha.2016.03.007.

Kováč, M., Márton, E., Oszczypko, N., Vojtko, R., Hók, J., Králiková, S., Plašienka, D., Klučiar, T., Hudáčková, N. & Oszczypko-Clowes, M., 2017: Neogene palaeogeography and basin evolution of the Western Carpathians, Northern Pannonian domain and adjoining areas. *Global Planet. Chang.,* 155, 133 – 154. http://doi.org/10.1016/j.gloplacha.2017.07.004.

Kováč, P. a Havrila, M., 1998: Inner structure of the Hronicum. *Slovak Geol. Mag.,* 4, 4, 275 – 280.

Kövér, S., Fodor, L., Judik, K., Németh, T., Balogh, K. & Kovács, S., 2009: Deformation history and nappe stacking in Rudabánya Hills (Inner Western Carpathians) unravelled by structural geological, metamorphic petrological and geochronological studies of Jurassic sediments. *Geodinamica Acta,* 2, 1 – 3, 3 – 29.

Kröll, A., Gnojek, I., Heinz, H., Jiricek, R., Meurers, B., Seiberl, W., Steinhauser, P., Wessely, G. & Zych, D., 1993: Wiener Becken und angrenzende Gebiete 1 : 200 000 mit Erläuterungen. *Wien, Geol. Bundesanst.*

Książkiewicz, M. (ed.), 1962: Atlas geologiczny Polski. Zagadnienia stratygraficzno-facjalne. Zeszyt 13, Kreda i starszy trzeciorzęd w polskich Karpatach zewnętrznych. 1 : 600 000. *Warszawa, Inst. Geol.*

Książkiewicz, M., 1965: Les cordilleres dans les mers cretacées et paléogens des Carpathes du Nord. *Bul. Soc. Géol. France, Sér.,* 7, 7, 443 – 455.

Lačný, A., Plašienka, D. & Vojtko, R., 2016: Structural evolution of the Turňa Unit constrained by fold and cleavage analyses and its consequences for the regional tectonic models of the Western Carpathians. *Geol. Carpath.,* 67, 2, 177 – 193.

Lefeld, J., Gaździcki, A., Krajewski, K. & Wojcik, K., 1985: Jurassic and Cretaceous lithostratigraphic units of the Tatra Mts. *Stud. geol. pol.,* 84, 1 – 93.

Lexa, J., Bezák, V., Elečko, M., Mello, J., Polák, M., Potfaj, M. & Vozár, J. (eds.), 2000: Geological map of the Western Carpathians and adjacent areas 1 : 500 000. *Bratislava, Min. Environ. Slovak Rep., Geol. Surv. Slovak Rep.*

Lexa, J. & Konečný, V., 1998: Geodynamic aspects of the Neogene to Quaternary volcanism. In: Rakús, M. (ed.): Geodynamic development of the Western Carpathians. *Bratislava, Geol. Surv. Slovak Rep.,* 219 – 240.

Maglay, J., Pristaš, J., Kučera, M. & Ábelová, M., 2009: Quaternary geological map of Slovakia Quaternary genetical (deposits) types. *Bratislava, Min. Environ. Slovak Rep., St. Geol. Inst. D. Štúr.*

Maglay, J., Pristaš, J., Nagy, A., Fordinál, K., Elečko, M., Havrila, M., Buček, S., Kováčik, M. (BA), Hók, J., Baráth, I., Kubeš, P., Kucharič, Ľ., Malík, P., Klukanová, A., Liščák, P., Ondrášik, M., Zuberec, J., Baláž, P., Čurlík, J., Ševčík, P., Kernátsová, J., Vaněková, H., Harčová, E., Boorová, D., Zlinská, A., Žecová, K., Siráňová, Z., Tuček, Ľ., Tkáčová, H. & Tkáč, J., 2011: Vysvetlivky ku geologickej mape Podunajskej nížiny – Trnavskej pahorkatiny 1 : 50 000. *Bratislava, Št. Geol. Úst. D. Štúra,* 322 pp.

Maheľ, M., 1983: Krížňanský príkrov, príklad polysériovej a polyštruktúrnej jednotky. *Miner. Slov.,* 15, 3, 193 – 216.

Maheľ, M., 1984: Nová koncepcia vývoja a stavby Západných Karpát. *Miner. Slov.,* 16, 6, 505 – 540.

Marschalko, R., 1986. Vývoj a geotektonický význam kriedového flyšu bradloveho pásma. *Bratislava, Veda, Vyd. Slov. Akad. Vied.,* 137 pp.

Márton, E., Grabowski, J., Tokarski, A. K. & Túnyi, I., 2016. Palaeomagnetic results from the fold and thrust belt of the Western Carpathians: an overview. In: Pueyo, E. L., Cifelli, F., Sussman, A. J. & Oliva-Urcia, B. (eds.): Palaeomagnetism in Fold and Thrust Belts: New Perspectives. *Geol. Soc. London, Spec. Publ.,* 425, 7 – 36.

Mello, J., 1979: Sú tzv. vyššie subtatranské príkrovy a silický príkrov súčasťou gemerika? Diskusia. *Miner. Slov.,* 11, 3, 279 – 281.

Mello, J. (ed.), Elečko, M., Pristaš, J., Reichwalder, P., Snopko, L., Vass, D. Vozárová, A., Gaál., Ľ., Hanzel, V., Hók, J., Kováč, P., Slavkay, M. & Steiner, A., 1997: Vysvetlivky ku geologickej mape Slovenského krasu 1 : 50 000. *Bratislava, GS SR, Vyd. D. Štúra,* 255 pp.

Mello, J., Reichwalder, P. & Vozárová, A., 1998: Bôrka Nappe: high-pressure relic from the subduction-accretion prism of the Meliata ocean (Inner Western Carpathians, Slovakia). *Slovak Geol. Mag.,* 4, 4, 261 – 273.

Mello, J. (ed.), Boorová, D., Buček, S., Filo, I., Fordinál, K., Havrila, M., Iglárová, Ľ., Kubeš, P., Liščák, P., Maglay, J., Marcim, D., Nagy, A., Potfaj, M., Rakús, M., Rapant, S., Remšík, A., Salaj, J., Siráňová, Z., Teťák, F., Zuberec, J., Zlinská, A. & Žecová, K., 2011: Vysvetlivky ku geologickej mape Stredného Považia 1 : 50 000. *Bratislava, Št. Geol. Úst. D. Štúra,* 378 pp.

Mišík, M., 1978: Continental, brackish and hypersaline facies in the Mesozoic of the Central Carpathians and the problems of emerged areas. In: Vozár, J. (eds.): Paleogeographical evolution of the West Carpathians. *Bratislava, Geol. Úst. D. Štúra,* 23 – 34.

Mišík, M., 1997: The Slovak part of the Pieniny Klippen Belt after the pioneering works of D. Andrusov. *Geol. Carpath.,* 48, 4, 209 – 220.

Mock, R., Sýkora, M., Aubrecht, R., Ožvoldová, L., Kronome, B., Reichwalder, P. & Jablonský, J., 1998: Petrology and stratigraphy of the Meliaticum near the Meliata and Jaklovce villages, Slovakia. *Slovak Geol. Mag.,* 4, 4, 223 – 260.

Nemčok, M., Hók, J., Kováč, P., Marko, F., Coward, M. P., Madarás, J., Houghton, J. J. & Bezák, V., 1998: Tertiary extension development and extension / compression interplay in the West Carpathian mountain belt. *Tectonophysics,* 290, 137 – 167.

Pécskay, Z, Lexa, J., Szakacs, A., Balogh, K., Seghedi, I., Konečný, V., Kovács, M., Marton, E., Kaličiak, M., Széky-Fux, V., Póka, T., Gyarmati, P., Edelstein, O., Rosu, E. & Žec, B., 1995: Space and time distribution of Neogene-Quaternary volcanism in the Carpatho-Pannonian Region. *Acta Vulcanol.,* 7, 2, 15 – 28.

Pečeňa, Ľ. & Vojtko, R., 2011: New knowledge about the geological setting of the Fatric Unit near Valaská Belá village (the Strážovské vrchy Mts., Western Carpathians). *Miner. Slov.,* 43, 1, 19 – 30 (in Slovak with English summary).

Pelech, O., Hók, J. & Józsa, Š., 2017: Turonian-Santonian sediments in the Tatricum of the Považský Inovec Mts. (Internal Western Carpathians, Slovakia*). Aust. J. Earth Sci.,* 110, 1, 19 – 33.

Pešková, I., Hók, J., Potfaj, M. & Vojtko, R., 2012: Structural interpretation of the Varín and Orava segments of the Klippen Belt (in Slovak). *Geol. Práce, Spr.,* 120, 51 – 64 (in Slovak with English summary.)

Picha, F. J., Stráník, Z. & Krejčí, O., 2006: Geology and hydrocarbons resources of the Outer Carpathians and their foreland, Czech Republic. In: Golonka, J. & Pícha, F. J. (eds.): The Carpathians and their foreland: Geology and hydrocarbon resources. *Mem. (Amer. Assoc. Petrol. Geol.),* 84, 49 – 175.

Pivko, D. & Vojtko, R., 2021: A review of travertines and tufas in Slovakia: Geomorphology, environments, tecntonic pattern, and age distribution. *Acta Geol. Slov.,* 13, 1, 49 – 78.

Plašienka, D., 1999: Tektochronológia a paleotektonický model jursko-kriedového vývoja centrálnych Západných Karpát. *Bratislava, Veda, Vyd. Slov. Akad. Vied,* 125 pp.

Plašienka, D., 2003: Dynamics of Mesozoic pre-orogenic rifting in the Western Carpathians. *Mitt. Österr. geol. Gesell.,* 94, 79 – 98.

Plašienka, D., 2018: The Carpathian Klippen Belt and types of its klippen – an attempt at a genetic classification. *Miner. Slov.,* 50, 1, 1 – 24.

Plašienka, D. & Soták, J., 2015: Evolution of the Late Cretaceous-Paleogene synorogenic basins in the Pieniny Klippen Belt and Adjacent Zones (Western Carpathians, Slovakia): Tectonic controls over growing orogenic wedge. *Ann. Soc. géol. Pol.,* 85, 43 – 76.

Prokešová, R., Plašienka, D. & Milovský, R., 2012: Structural pattern and emplacement mechanisms of the Krížna cover nappe (Central Western Carpathians). *Geol. Carpath.,* 63, 1, 13 – 32.

Rakús, M. & Sýkora, M., 2001: Jurassic of Silicicum. *Slovak Geol. Mag.,* 7, 1, 53 – 84.

Schmid, S. M., Fügenschuh, B., Kounov, A., Maţenco, L., Nievergelt, P., Oberhänsli, R., Pleuger, J., Schefer, S., Schuster, R., Tomljenović, B., Ustaszewski, K. &van Hinsbergen, D. J. J., 2020: Tectonic units of the Alpine collision zone between Eastern Alps and western Turkey. *Gondwana Res.,* 78, 308 – 374.

Slávik, J., 1976: Zemplinikum – možná nová tektonická jednotka centrálnych Karpát. *Geol. Práce, Spr.,* 65, 7 – 19.

Soták, J., Pereszlényi, M., Marschalko, R., Milička, J. & Starek, D., 2001: Sedimentology and hydrocarbon habitat of the submarine-fan deposits of the Central Carpathian Paleogene Basin (NE Slovakia). *Mar. Petr. Geol.,* 18, 87 – 114.

Soták, J., Elbra, T., Pruner, P., Antolíková, S., Schnabl, P., Biroň, A., Kdýr, Š. & Milovský, R., 2021: End-Cretaceous to middle Eocene events from the Alpine Tethys: Multi-proxy data from a reference section at Kršteňany (Western Carpathians). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 579, 110571. https://doi.org/10.1016/j.palaeo.2021.110571

Straka, P., 1980: O veku série foederata. *Geol. Práce, Spr.,* 75, 57 – 62.

Šefara, J., Bielik, M., Vozár, J., Katona, M., Szalaiová, V., Vozárová, A., Šimonová, B., Pánisová, J., Schmidt, S. & Götze, H.-J., 2017: 3D density modelling of Gemeric granites of the Western Carpathians. *Geol. Carpath.,* 68, 3, 177 – 192.

Šujan, M., Rybár, S., Kováč, M., Bielik, M., Majcin, D., Minár, J., Plašienka, D., Nováková, P. & Kotulová, J., 2021: The polyphase rifting and inversion of the Danube Basin revised. *Global Planet. Change,* 196, 103375, https://doi.org/10.1016/j.gloplacha.2020.103375.

Teťák, F., 2021: Lithology and position of the Biele Karpaty Unit SE of Lednica (Biele Karpaty Mts., Western Carpathians). *Miner. Slov.,* 53, 1, 47 – 56.

Teťák, F. & Potfaj, M. (eds.), Havrila, M., Filo, I., Pešková, I., Boorová, D., Žecová, K., Laurinc, D., Olšavský, M., Siráňová, Z., Buček, S., Kucharič, Ľ., Gluch, A., Šoltés, S., Pažická, A., Iglárová, Ľ., Liščák, P., Malík, P., Fordinál, K., Vlačiky, M. & Köhler, E., 2015: Vysvetlivky ku geologickej mape Bielych Karpát (južná časť) a Myjavskej pahorkatiny. *Bratislava, Št. Geol. Úst. D. Štúra,* 306 pp.

Teťák, F., Pivko, D. & Kováčik, M., 2019: Depositional systems and paleogeography of Upper Cretaceous-Paleogene deep-sea flysch deposits of the Magura Basin (Western Carpathians). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 533, 1 – 21.

Vass, D., 2002: Litostratigrafia Západných Karpát: neogén a budínsky paleogén. *Bratislava, Št. Geol. Úst. D. Štúra,* 202 pp.

Vojtko, R., Hók, J., Kováč, P., Madarás, J. & Filová, I., 2000: Geological structure and tectonic evolution ofthe Southern Veporicum. *Slovak Geol. Mag.,* 6, 2 – 3, 287 – 292.

Zoubek, V., 1957: Hranice gemerid s veporidami. *Geol. Práce, Zoš.,* 46, 38 – 50.

THE KARPATIAN (LATE BURDIGALIAN) DEEP-WATER CALCAREOUS "SCHLIER" FACIES AT THE CEROVÁ-LIESKOVÉ SITE

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The Cerová-Lieskové site is located at the foothills of the Malé Karpaty Mountains (Vienna Basin, Centarl Paratethys; 48°35'18.6"N; 17°24'09.3"E). Outcropped uppermost Burdigalian – ?lowermost Langhian (Karpatian–?Badenian) massive, locally laminated calcareous clay and clayey silt *"schlier"* with thin tempestites (up to 5 mm thick, exceptionally up to 30 mm) belong to the Lakšáry Formation (Špička and Zapletalová, 1964). Cropped out sediments were formerly used as addition to peat by producing vitahum fertiliser. Currently (spring 2022), due to a rapid weathering only south-western circa 18 m high wall of the quarry is exposed.

Exact relief of the Karpatian Vienna Basin area is difficult to reconstruct due to the reconfiguration of the whole Carpathian area during the Styrian tectonic phase around the end of the Karpatian, when the mountain topography transitioned toward modern conditions. Horst of the Malé Karpaty Mts. begun to arise, while graben structures formed sedimentary depocenters of the Vienna Basin NE part. The sea floor of the basin was very irregular, with several submarine elevations (ridges), representing tilted blocks of underlying Alpine and Western Carpathian units (Fodor, 1995), which probably started to uplift at that time. The Cerová-Lieskové site was situated on the slope of such structure (uplifting block of the Malé Karpaty Mts). Terrestrial plant assemblage demonstrates subtropical climatic conditions with paleovegetation represented by evergreen woodland with pines and grasses in undergrowth, similar to vegetation inhabiting coastal brackish marshes today (Kvaček et al., 2014).

Fossil association found in the site demonstrates relatively warm global interval of emerging Mid-Miocene Climatic Optimum. These association consists of wide variety of micro and macro biota: calcareous nannoplankton, diatoms, freshwater algae, plant debris (wood fragments, leaves and cones), radiolarians, foraminifers, siliceous sponges, ostracods, bryozoans, nautilids, coleoids, bivalves and gastropods (including abundant pteropods), scaphopods, echinoderms (regular and irregular sea-urchins, sea-stars, brittle stars), crustaceans, fishes, bathyal sharks and terrestrial insects.

Some fossil groups from this site were already studied more deeply. At least two demosponge species (most probably belonging to Polymastidae, Hadromedrida) are preserved intact but flattened (Lukowiak et al., 2014). Other exceptionally preserved fossils are nautilid jaws with chitinous lamellae still present, similarly preserved coleoid jaws, organic black bands around the nautilid shell edge (Schlögl et al., 2011), articulated skeletons of several *Callianopsis* species, articulated isopod moults with both parts of the exoskeleton preserved in situ (Hyžný and Schlögl, 2011). Mollusc faunas were examined in detail by Harzhauser et al. (2011). Nine new species of invertebrates and 4 new species and 1 new genus of vertebrates were described based on here collected material.

The plant assemblage consists of conifers represented by foliage of *Pinus hepios* and *Tetraclinis salicornioides*, a seed cone of *Pinus* cf. *ornata*, and by pollen of the *Cupressaceae*, *Pinaceae*, *Pinus* sp. and *Cathaya* sp., angiosperms are represented by *Cinnamomum polymorphum*, *Platanus neptuni*, *Potamogeton* sp. and lauroid foliage, by pollen of *Liquidambar* sp., *Engelhardia* sp. and *Craigia* sp., in particular also by infructescences (*Palaeotriticum*, including *P. mockii* and *P. carpaticum*, probably representing herbaceous monocots that inhabited coastal marshes, similar to the living grass *Spartina*).

A late Karpatian age of the deposits is determined based on the cooccurrence of the foraminiferal taxa *Uvigerina graciliformis* and *Trilobatus bisphericus* in combination with the absence of *Praeorbulina*. The Lowest Occurrence (LO) of *U. graciliformis* delineates the base of the Karpatian stage, the LO of *G. bisphericus* occurs within M4b Zone (*sensu* Berggren et al., 1995) and correlates with the late Karpatian. The LO of *Praeorbulina* occurs at the base of the Badenian stage (Cicha and Rögl, 2003).

Planktic foraminiferal association is composed mainly of temperate shallow dwellers, globigerinids [*Globigerina praebulloides* (accepted as *Globigerinella obesa*) and *G. bulloides*] accompanied by tenuitellinids, locally with mass abundances of *Cassigerinella boudecensis*. Rare occurrences of *Trilobatus bisphericus* (*sensu* Cicha et al., 1998) and *G. triloba* indicate warm to temperate water. Benthic foraminiferal assemblages are dominated by infauna to deep-infauna; *Bolivina fastigia*, *Bolivina hebes*, *Bulimina marginata*, *Bulimina elongata* and *Uvigerina*

Fig. 1. Fosils of the Cerová-Lieskové site.
1 – View on the outcrop wall excavated in 2021; 2 – *Bathysiphon filiformis* Sars; 3 – intact sponge; 4 – *Aturia* sp.; 5 – *Parvamussium felsineum* (Foresti); 6 – *Brissopsis ottnangiensis* Hoernes; 7: *Lovenia mortenseni* Čtyroký; 8: *Callianopsis marianae* Hyžný et Schlögl (m); 9 – *Callianopsis marianae* Hyžný et Schlögl (f).

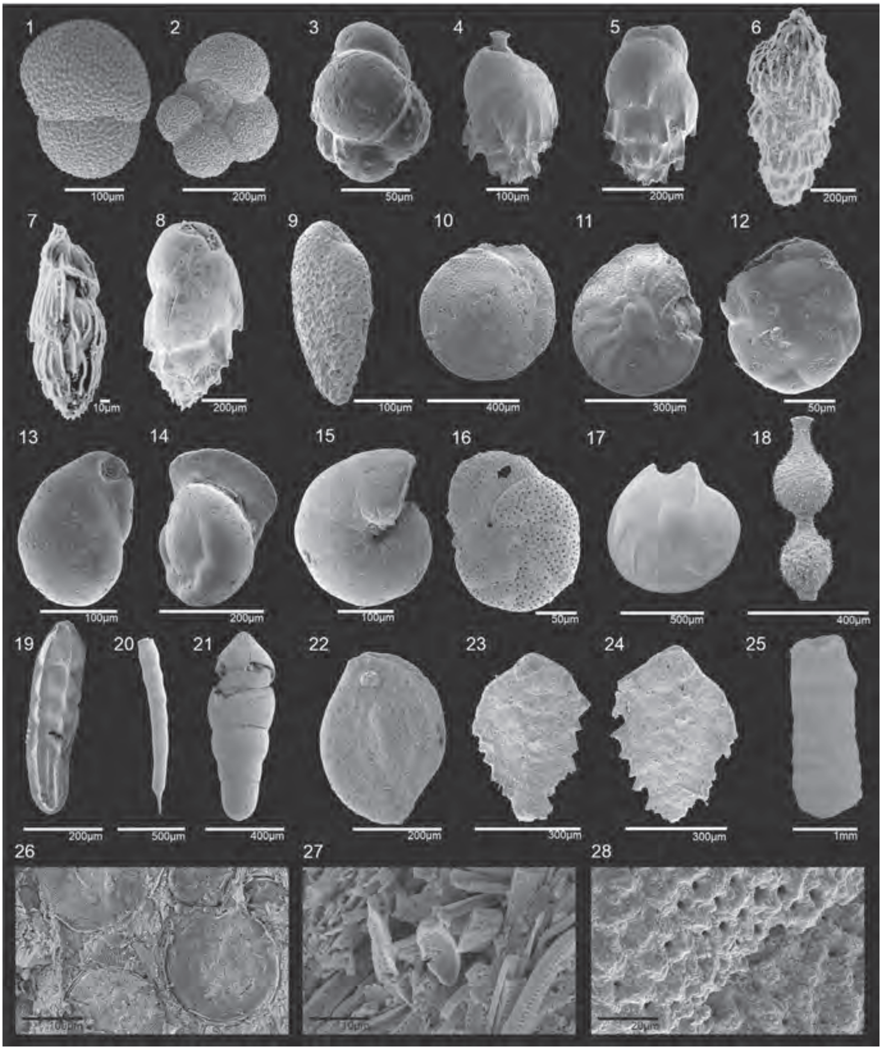

Fig. 2. Foraminifera from "schlier" sediment of the Cerová-Lieskové site.
1, 28 – *Trilobatus bisphericus* (Todd), s14; 2 – *Globigerina bulloides* d'Orbigny, s41; 3 – *Cassigerinella boudecensis* Pokorný, s41; 4 – *Uvigerina acuminata* Hosius, s45; 5 – *U.* cf. *uniseriata* Jedlitschka; 6 – *U. graciliformis* Papp et Turnovsky, s16; 7 – *Trifarina* cf. *angulosa* (Williamson, 1858), s6; 8 – *Bulimina buchiana* d'Orbigny, s41; 9 – *Bolivina hebes* MacFayden, s42; 10 – *Heterolepa dutemplei* (d'Orbigny), s14; 11 – *Cibicidoides ornatus* (Cicha et Zapletalová), s16; 12 – *Cassidulina laevigata* d'Orbigny, s41; 13 – *Globocassidulina subglobosa* (Brady), s16; 14 – *Hansenisca soldanii* (d'Orbigny), s16; 15 – *Melonis pompilioides* (Fichtel & Moll), s13; 16: *Valvulineria complanata* (d'Orbigny); 17: *Lenticulina* cf. *clypeiformis* (d'Orbigny), s14; 18 – *Amphicoryna hirsuta* (d'Orbigny), s14; 19 – *Plectofrondicularia digitalis* (Neugeboren), s13; 20 – *Laevidentalina elegans* (d'Orbigny), s13; 21 – *Pseudonodosaria brevis* (d'Orbigny), s13; 22 – *Spirosigmoilina tenuis* (Czjzek), s42; 23, 24 – *Spirorutilus carinatus* (d'Orbigny, 1846), s43; 25 – *Bathysiphon filiformis* Sars, s45; 26 – diatom frustules, s15 bedding plane; 27 – diatom frustules, s15 cross section; 28 – *Trilobatus bisphericus* (Todd), detail of the aperture, s14.

spp. represent dysoxic to suboxic index species. Rarely, in the upper part of the profile, the oxiphylic genera *Cibicides* and *Cibicidoides* occur.

Analysed samples from upper two thirds of profile yield Kaiho's (1994) BFOI index values ranging from −30 to −20 (when oxic indicators are absent), and from 2.2 to 4.2 (when oxic indicators are present). BFOI index values between 0 and 15 correspond to dissolved oxygen ranging from 1.2 to 2 ml/l (e.g., Tyson and Pearson, 1991) point to suboxic conditions.

Paleodepth analyses (following Hohenegger, 2005) allow us to estimate water depths of 240–330 m. Based on the methods of Murray (1973, 1991), samples show Fisher α values ranging from 5.5 to 8 and Shannon H values from 1.9 to 2.6 typical for the shelf and deep-sea assemblages. In the lower part of the profile a very abundant *Bathysiphon filiformis* occur, reaching up to 10 cm long almost intact tests. This assemblage enriched by *Spiroloculina canaliculata*, *Lenticulina calcar* and *Uvigerina* sp. probably represents recolonization of the sea-floor after slide of siliciclastic material from the onshore sedimentary facies.

References:

Cicha, I., Rögl, F., Rupp, Ch. & Čtyroká, J. (eds.), 1998: Oligocene-Miocene foraminifera of the Central Paratethys. *Abh. Senckenberg. naturforsch. Gesell.,* 549, 325 p.

Cicha, I. & Rögl, F., 2003. Definition of the Karpatian Stage. In: Brzobohatý, R., Cicha, I., Kováč, M., Rögl, F. (eds.): The Karpatian, a Lower Miocene stage of the Central Paratethys. *Brno, Masaryk University,* 15–20.

Harzhauser, M., Mandic, O. & Schlögl, J., 2011: A late Burdigalian bathyal mollusc fauna from the Vienna Basin (Slovakia). *Geol. Carpath.,* 62, 3, 211–231.

Hohenegger, J., 2005: Estimation of environmental paleogradient values based on presence/absence data: a case study using benthic foraminifera for paleodepth estimation. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 217, 115–130.

Hyžný, M. & Schlögl, J., 2011: An Early Miocene deep-water decapod crustaceans faunule from the Vienna Basin (Western Carpathians, Slovakia). *Palaeontology,* 54, 2, 323–349.

Kaiho, K., 1994: Benthic foraminiferal dissolved-oxygen index and dissolved-oxygen levels in the modern ocean. *Geology,* 22, 719–722.

Kvaček, Z., Teodoridis, V., Kováčová, M., Schlögl, J. & Sitár, V., 2014: Lower Miocene plant assemblage with coastal-marsh herbaceous monocots from the Vienna Basin (Slovakia). *Geol. Carpath.,* 65, 3, 227–239.

Lukowiak, M., Pisera, A. & Schlögl, J., 2014: Bathyal sponges from the late Early Miocene of the Vienna Basin (Central Paratethys, Slovakia). *Paläont. Z.,* 88, 3, 263–277.

Murray, J. W., 1973: Distribution and Ecology of Living Benthic Foraminiferids. *London, Heinemann Education Books,* 274 p.

Murray, J. W., 1991: Ecology and Paleoecology of Benthic Foraminifera. *Harlow, Longman Scientific Technical,* 397 p.

Tyson, R. V. & Pearson T. H. (eds.), 1991: Modern and ancient continental shelf anoxia. *Geol. Soc. Spec. Publ.,* 58, 1–24.

2ND STOP – SNEŽNICA SECTION

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Location and geological setting

Another important section encovering the JKB sequence in the western sector of the Pieniny Klippen Belt is named as the Snežnica section. The section is exposed by hundred meters tall wall of a freshly abandoned quarry (N 49°16’14.35”; E 18° 46’31.18”) in a steep SE slope of the Snežnica hill encovering inverted layer sequence (Fig. 1).

It is located on the left side above the local road to the Snežnica village. From the whole sequence outcropping in the quarry, we selected interval belonging to the Late Jurassic–Early Cretaceous, which was further documented in detail and studied for their bio- and chemostratigraphy. Totally 117 samples have been selected for thin-sections which were used for microfacies analyses and for documentation of succession of stratigraphically important calcareous microfossils – calpionellids and calcareous dinoflagellates. For the study of calcareous nannofossils, 62 samples were taken from the section in the length of 47.1 m.

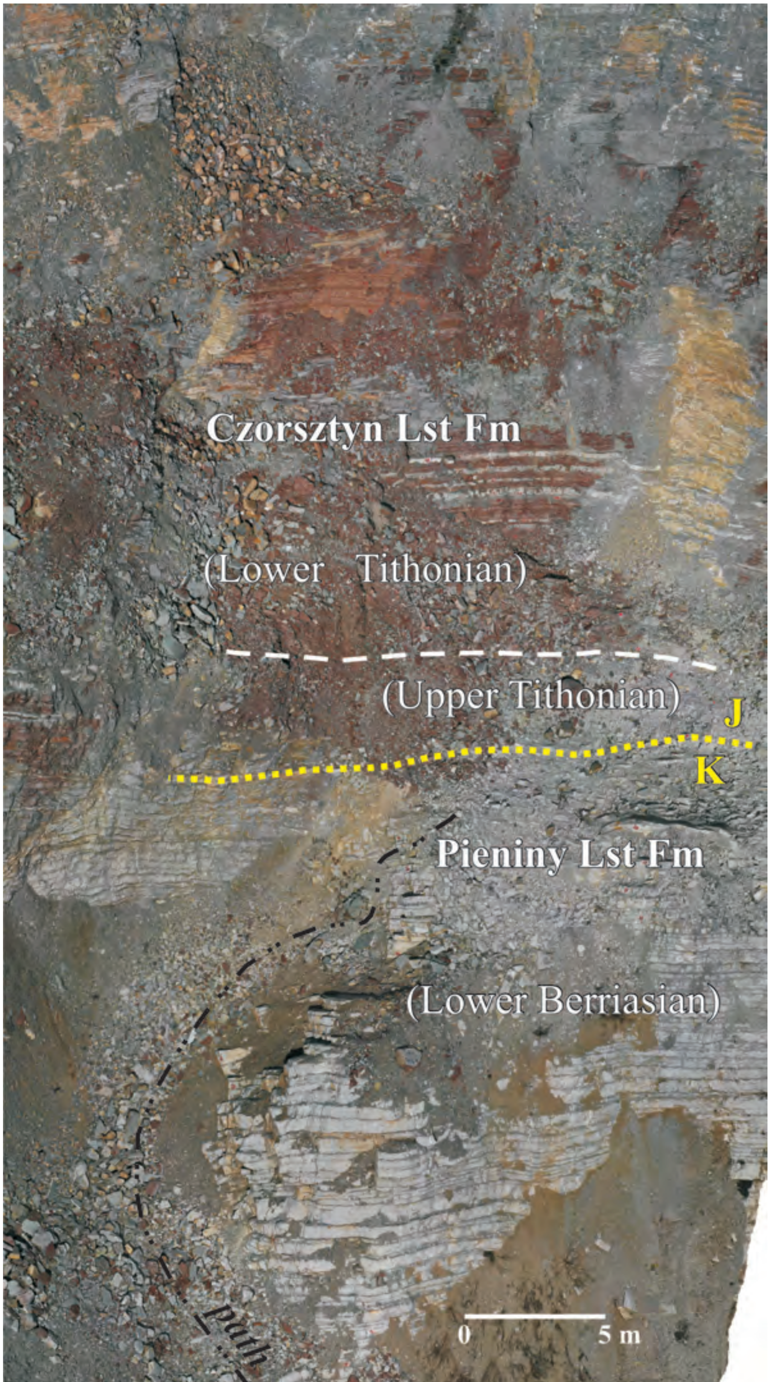


Fig. 1a. Aerial view of the Snežnica Quarry with indication of the J/K section studied. Photo by M. Marciš and K. Fekete

Fig. 1b. Detailed view of the Snežnica Quarry with indication of the J/K section studied. Photo by K. Fekete

Microfacies, calpionellid and calcareous dinocyst zonation

Microfacies were interpreted according to Dunham's (1962). Standard microfacies types (SMFs) and facies zones (FZs) as proposed Wilson (1975) and modified by Flügel (2004) were determined. Standard SMF2, SMF3 and SMF4 microfacies were recognized. They characterize basin – slope environment of deposition (FZ 3–4). Calpionellid zonation of Reháková and Michalík (1997) and calcareous dinoflagellate zonation sensu Reháková (2000) were applied. Limestone sequence studied in the Snežnica section is dated by a succession of calcareous dinoflagellates as the Late Oxfordian (Parvula Zone) to Early Tithonian Malmica Zone and continuously, on the base of calpionellid succession as late Early Tithonian (Chitinoidella Zone, Dobeni Subzone) to late Early Berriasian (standard Calpionella Zone, Elliptica Subzone; Fig. 2).

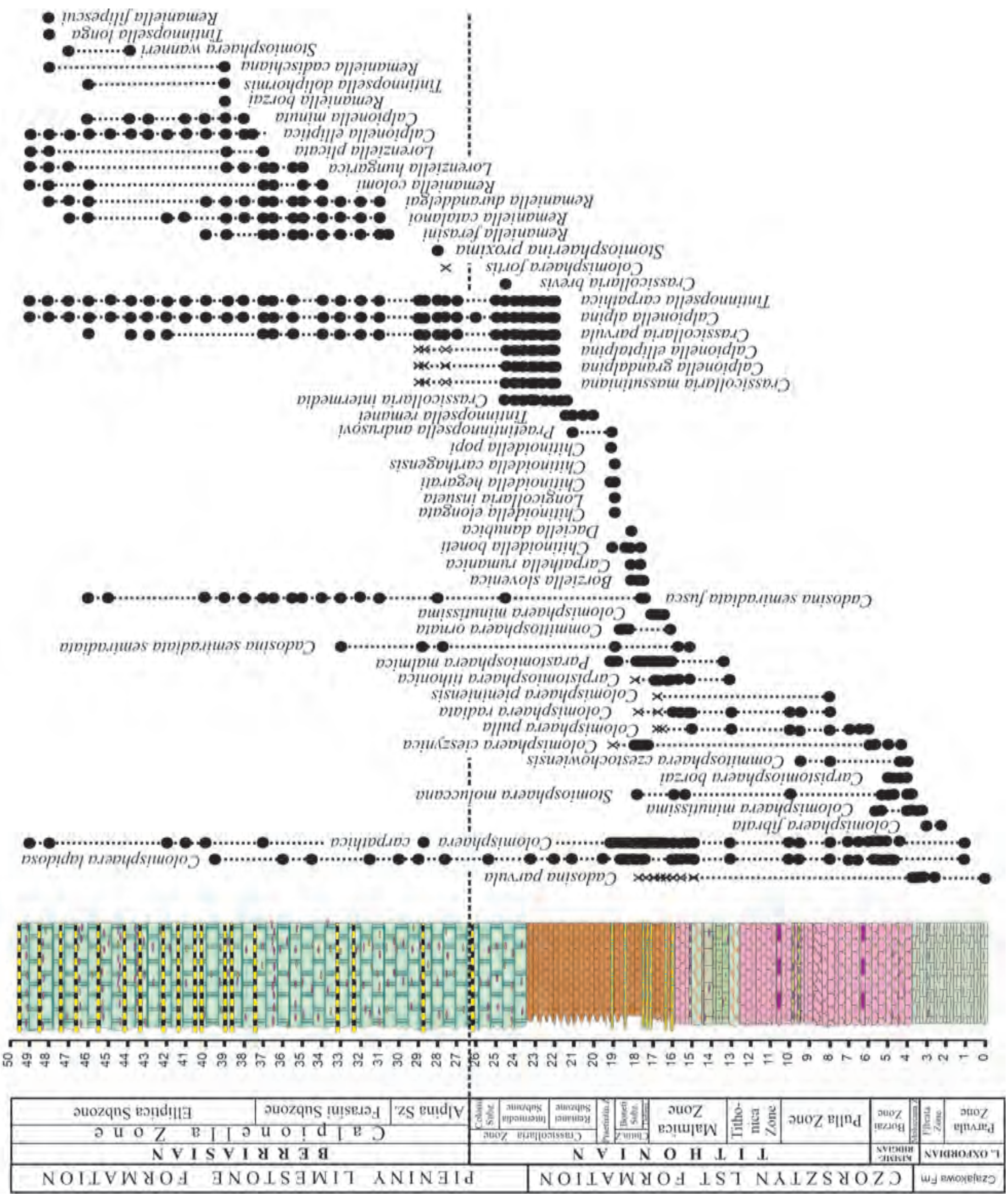


Fig. 2. Lithological log of the Snežnica J/K sequence studied, distribution of calpionellids and calcareous dinoflagellates, calpionellid and cyst zonations.

Czajakowa Formation (Birkenmajer, 1977)

Late Oxfordian Parvula Zone (sensu Reháková, 2000); Sn-0; 1.1; 2; and 2.1 samples

Grey, laminated siliceous limestones of *Bositra* microfacies, *Bositra*-radiolaria-spiculite and spiculite microfacies (packstone, passing locally to wackestone; SMF 2) contains small fragments of thin *Bositra* shells (showing transport), aptychi, crinoid columnalia fragments, silicified sponge spicules, and rare *Cadosina parvula*, *Colomisphaera lapidosa*, *Colomisphaera carpathica* cysts. Radiolarian tests filled by microgranular SiO_2 contain neomorphic calcite crystals. Matrix is locally impregnated by Fe-hydroxide and in some cases penetrated by thin calcite filled veins and fractures.

Late Oxfordian Fibrata Zone (sensu Reháková, 2000); Sn-2.2 and Sn-3.1 samples

Grey-brown laminated detrital siliceous limestones in *Bositra*-spiculite and *Bositra* microfacies (packstone; SMF 2) with accumulations of pyrite on the surface and with chert nodules. Locally graded and sorted *Bositra* filaments are dominating over radiolarians, sponge spicules, rare crinoids, aptychi and cysts of *Cadosina parvula* a *Colomisphaera fibrata*, *Colomisphaera minutissima*.

Early Kimmeridgian Parvula Acme Zone (sensu Reháková, 2000); Sn-3.2 sample

Brown laminated and bioturbated biomicrite limestone (wackestone; SMF2-3) contains small fragments of *Bositra* filaments, crinoid columnalia and aptychi, common cysts of *Cadosina parvula* and less frequent *Colomisphaera minutissima*. Slightly recrystallized matrix contains pyrite nests.

Kimmeridgian Moluccana Zone (Nowak, 1976); Sn-3.3 sample

Pinkish-grey, fine-grained limestone beds are separated by thin clay laminae. They contain belemnites and abundant pyrite. Biomicrite (wackestone, SMF 2-3) is bioturbated, it contains laminae rich in resedimented bioclasts (abundant *Cadosina parvula*). The microfossils are represented by small fragments of *Bositra* filaments, crinoids (also planktonic *Saccocoma* sp.), aptychi and cysts of *Stomiosphaera moluccana*, *Colomisphaera minutissima*. Matrix is slightly recrystallized being locally enriched in pyrite.

Czorsztyn Limestone Formation (Mojsisovics, 1867)

Late Kimmeridgian Borzai Zone (Nowak, 1976); Sn-4; 4.1; 4.2; 5; and 5.2 samples

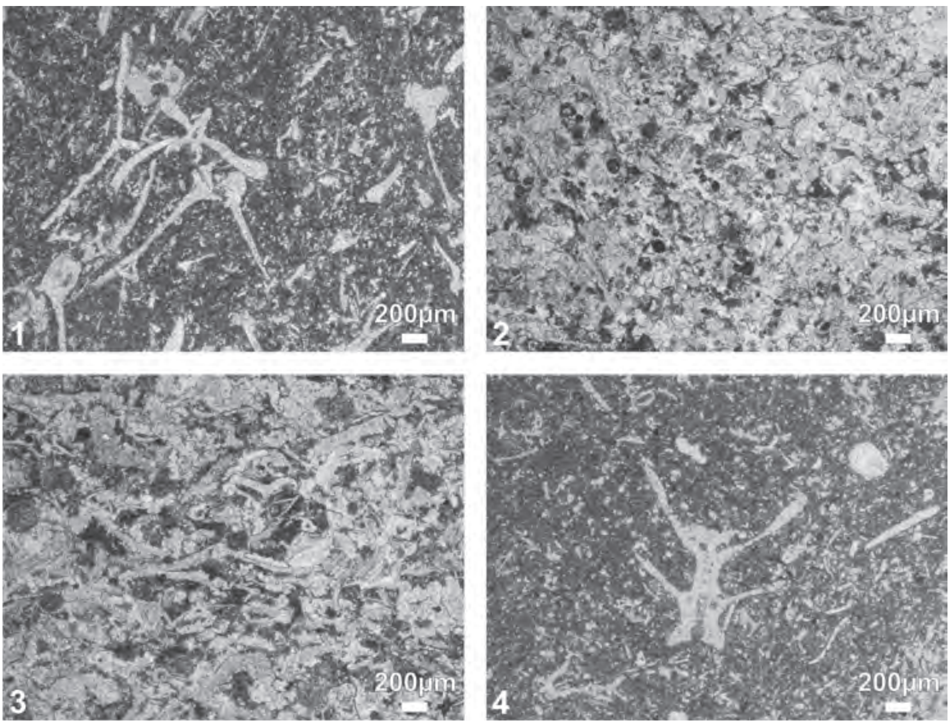


Fig. 3. Late Jurassic microfacies in the Snežnica section: 1 – *Saccocoma-Globochaete* wackestone to packstone. Sample Sn 15; 2 – Pelbioclastic *Saccocoma* packstone. Sample Sn 16.3; 3 – *Saccocoma* packstone. Sample Sn 17.3; 4 – *Saccocoma–Globochaete* wackestone. Samples Sn 19.2.

Reddish brown and brown nodular limestone is composed of biomicrite of *Saccocoma*-radiolarian or *Saccocoma* microfacies (packstone; SMF 2), and laminated biomicrite of *Saccocoma-Globochaete* microfacies (packstone or wackestone; SMF2–3, Fig. 3). Planktonic crinoids *Saccocoma* sp. dominate over *Globochaete alpina* spores, fragments of aptychi, filaments, ostracods, foraminifera with calcitic tests, crinoid ossicles and columnalia, cysts of *Carpistomiosphaera borzai*, *Colomisphaera lapidosa*, *Colomisphaera carpathica*, *Colomisphaera cieszynica*, *Colomisphaera minutissima*, *Commitosphaera czestochowiensis*, *Stomiosphaera moluc-*

cana, *Stomiosphaera* sp., *Cadosina parvula.* Some of bioclasts are bearing marks of microborings, some of them being pyritized or silicified. Few samples contain fine siliciclastic admixture (quartz grains and muscovite). The matrix is sometimes affected by slight dolomitization; stylolites and fractures are frequently impregnated by Fe-hydroxides. Slightly recrystallized matrix contains scattered pyrite cubes (locally forming nests). On the base of *Saccocoma* elements analysed, it seems that Early Tithonian S-3: Sacoccoma Zone sensu Benzaggagh et al. (2015) starts here little bit earlier.

Early Tithonian Pulla Zone (Reháková, 2000); Sn-6; 6.5; 7; 8; 9.5; and Sn-10 samples

In the upper part of thin bedded reddish brown and brown nodular or pseudo-nodular limestones (locally with greenish nodules) slightly laminated siliceous limestones with stratiform cherts occur. Laminated locally bioturbated biomicrite packstone of *Globochaete-Saccocoma* microfacies rich in belemnites locally passes to wackestone or wackestone (SMF 2–3). *Saccocoma* sp. and *Globochaete alpina* prevail among bioclasts being accompanied by less frequent filaments, ostracods, bivalves, foraminifera (*Lenticulina* sp., *Spirilina* sp.), crinoids (*Pentacrinus* sp.), aptychi, calcified radiolarians and cysts of *Colomisphaera pulla*, *Colomisphaera lapidosa*, *Colomisphaera cieszynica*, *Colomisphaera carpathica*, *Colomisphaera radiata*, *Colomisphaera pieniniensis*, *Committosphaera czestochowiensis.* Bioclasts are locally phosphatized; some of them are silicified. Bioclasts in bed Sn7 are chaotically arranged. Pyrite is scattered in matrix which is slightly recrystallized and rich in stylolites which are impregnated by Fe-hydroxides. Some of samples contain fine siliclastic admixture (quartz grains and muscovite).

Early Tithonian Tithonica Zone (sensu Lakova et al., 1999); Sn-11; 12; and Sn-13 samples

Greenish-grey fine-grain limestones with cherty layers, thin bedded grey laminated limestones, reddish brown nodular and pseudo nodular limestones with chert nodules and ammonite molds.

They are biomicrite locally laminated packstone or wackestone of *Saccocoma–Globochaete* microfacies (SMF 2–3). Packstone locally pass to wackestone with chaotically arranged bioclasts. Besides dominating *Saccocoma* sp. and *Globochaeta alpina*, the rock contains crinoid columnalia, foraminifera, *Spirilina* sp., aptychi, calcified radiolarians (locally filled by chalcedony), sponge spicules, cysts of *Colomisphaera tithonica*, *Colomisphaera pulla*, *Colomisphaera lapidosa*, *Colomisphaera carpathica*, *Colomisphaera radiata*, *Cadosina semiradiata semiradiata*, *Cadosina parvula, Stomiosphaera moluccana* (Fig. 4). Some of bioclasts are phosphatized or silicified. Matrix of packstone with rich stylolites and scattered pyrite is slightly recrystallized.

Early Tithonian Malmica Zone (sensu Nowak, 1968); Sn-13.3; 14.3; 15; 15.1; 15.2; 15.3; 15.4; 16; 16.1; 16.2; 16.3; 16,4; 17; 17.1; and Sn-17.2 samples

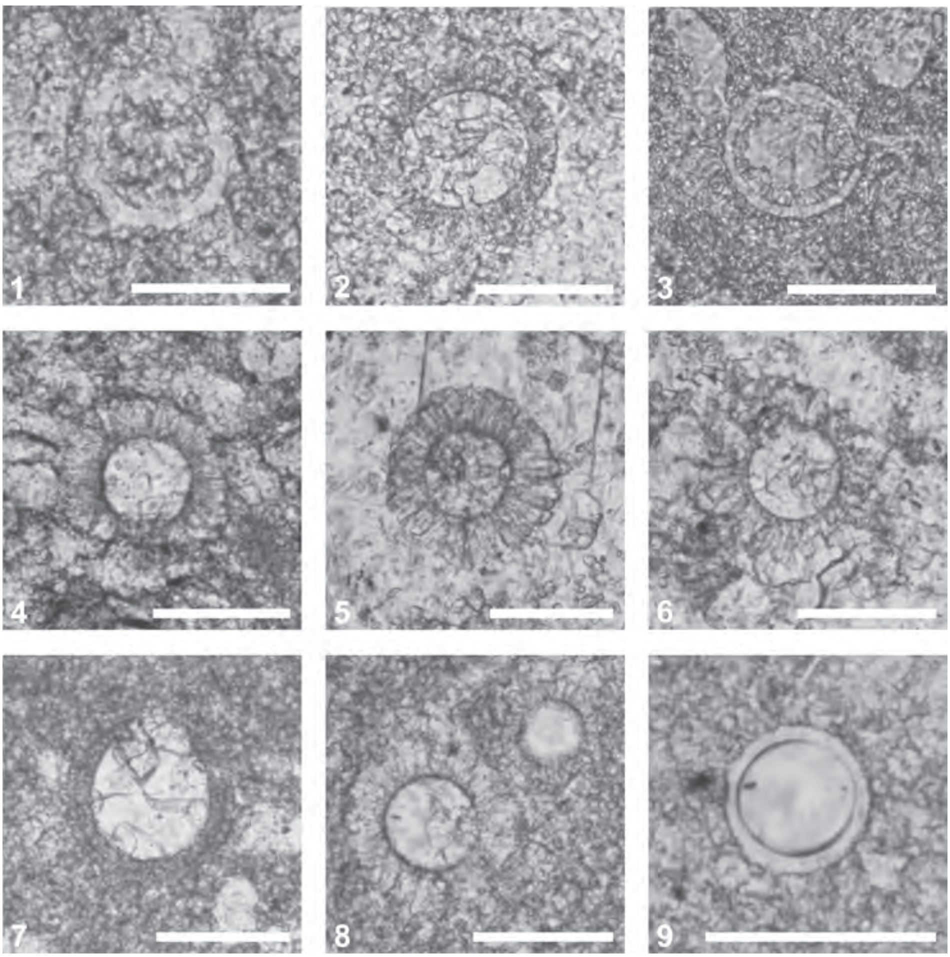


Fig. 4. Early Tithonian dinoflagellate cysts from the Snežnica section: 1 – *Stomiosphaera moluccana* Wanner, Sn 10; 2 – *Carpistomiosphaera tithonica* Nowak, Sn 15; 3 – *Parastomiosphaera malmica* (Borza), Sn 13.3; 4 – *Colomisphaera carpathica* (Borza), Sn 15.4; 5 – *Colomisphaera cieszynica* Nowak, Sn 17.3; 6 – *Committosphaera ornata* (Nowak), Sn 18.1; 7 – *Cadosina semiradiata semiradiata* (Wanner), Sn 20.5; 8 – *Colomisphaera carpathica* (Borza) and *Colomisphaera lapidosa* (Vogler), Sn 28.9, 9 – *Cadosina semiradiata fusca* (Wanner), Sn 43.5. Scale bar is 50 µm.

Reddish brown and brown nodular and pseudo-nodular limestones with local thin clayey intercalations, light grey fine-grained (allodapic) limestones with brown cherts.

Pelbiomicrite, bioturbated packstone and chiefly wackestone of *Globochaete*-*Saccocoma* microfacies or packstone of *Saccocoma* microfacies were determined. They represent SMF 2 and SMF 4. *Saccocoma* sp. and *Globochaete alpina* spores are still dominating, being accompanied by fragments of ostracods, bivalves, foraminifera, aptychi, echinoids, cysts of frequent *Parastomiosphaera malmica* (Fig. 4), rare *Colomisphaera carpathica*, *Colomisphaera minutissima*, *Colomisphaera lapidosa*, *Colomisphaera pieniniensis*, *Colomisphaera pulla*, *Committosphaera ornata*, *Cadosina semiradiata semiradiata*, *Cadosina semiradiata fusca*, *Cadosina parvula*, *Carpistomiosphaera tithonica*, *Colomisphaera radiata*, *Stomiosphaera moluccana*, *Stomiosphaera* sp. In several layers (Sn 14.3, 16.1 and Sn 17), bioclasts are arranged chaotically. Matrix and bioclasts are locally silicified. On the base of analysed *Saccocoma* elements, this interval could be correlatable with the Saccocoma S4 Zone (Benzaggagh et al., 2015) or with the Darwini-Semiforme ammonite Zone.

Early Tithonian Chitinoidella Zone, Dobeni Subzone (*sensu* Grandesso, 1977 and Borza, 1984); Sn-17.3; 17.4; and Sn-17.5 samples

Pale green fine-grained limestones: pelbiomicrite, laminated (locally with graded allochems) packstone of *Saccocoma*, *Globochaete*–*Saccocoma*, and *Saccocoma*–crinoidal microfacies – SMF-2, 3, 4 with chert nodules. *Saccocoma* sp. is dominating over *Globochaete alpina*, crinoid columnalia and rare foraminifera, aptychi, bivalve fragments, microgranular calpionellids, *Borziella slovenica*, cysts of *Colomisphaera carpathica*, *Colomisphaera cieszynica* and *Parastomiosphaera malmica* prevail over redeposited *Carpistomiosphaera tithonica*, *Cadosina parvula* and *Colomisphaera radiata* cysts.

Late Tithonian Chitinoidella Zone, Boneti Subzone (*sensu* Grandesso, 1977 and Borza, 1984); Sn 17,6; 18; 18.1; 18.2; 18.3; and Sn-18.9 samples

Reddish brown- and brown nodular limestones with thin marly layers, pale grey to green fine-grained (allodapic) limestones is built of slightly bioturbated, locally laminated biomicrite with graded bioclasts:

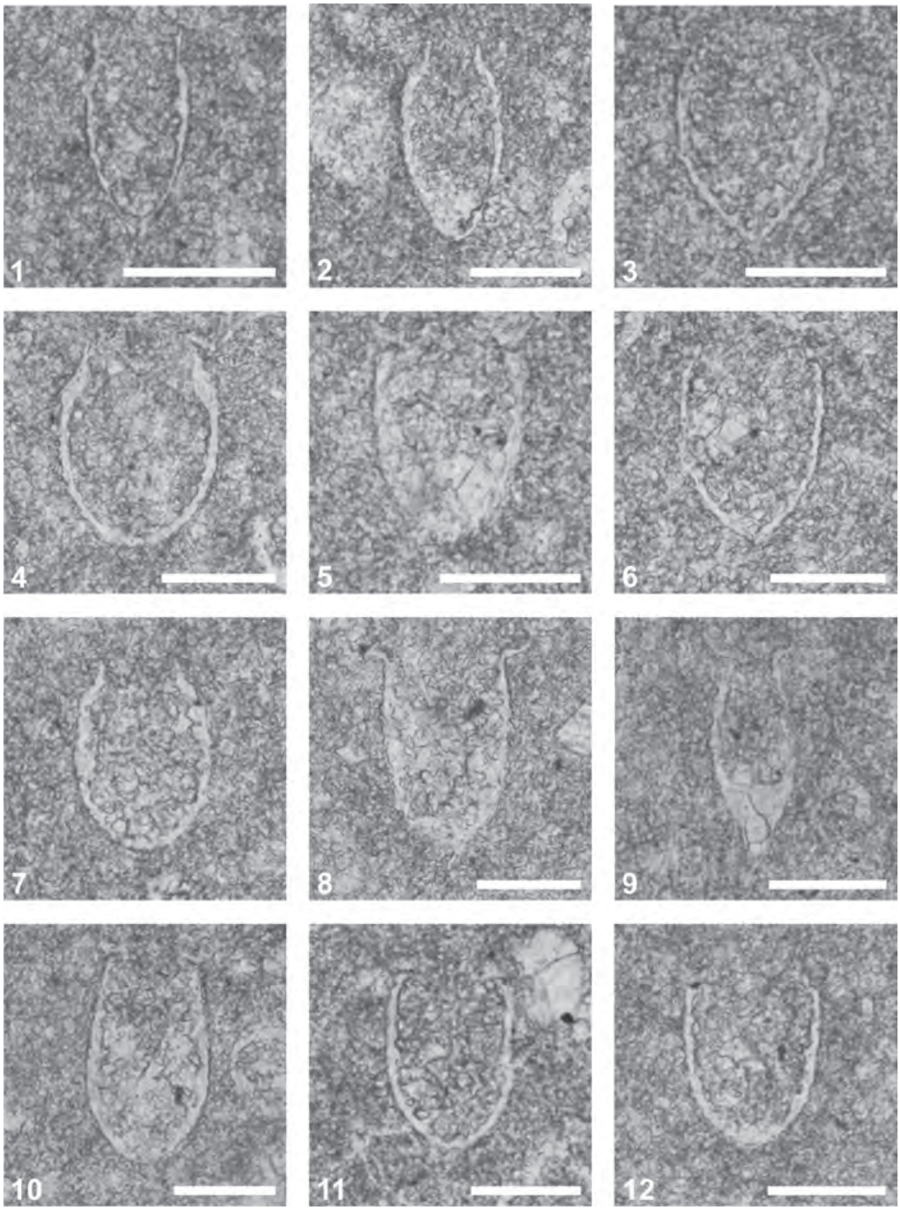


Fig. 5. Late Tithonian-Early Berriasian calpionellids from the Snežnica section: 1 – *Crassicollaria parvula* Remane, Sn 25; 2 – *Crassicollaria colomi* Doben, Sn 36.5; 3 – *Tintinopsella doliphormis* (Colom) Sn 31.5; 4 – *Calpionella alpina* Lorenz, Sn 35.5; 5 – *Remaniella ferasini* (Catalano), Sn 33; 6 – *Remaniella colomi* Pop, Sn 35; 7 – *Calpionella elliptica* Cadish, Sn 44.5; 8 – *Tintinopsella longa* (Colom), Sn 44.5; 9 – *Tintinopsella subacuta* (Colom), Sn 45.5; 10 – *Remaniella cadischiana* (Colom), Sn 39; 11 – *Remaniella borzai* Pop, Sn 39.5; 12 – *Remaniella duranddelgai* Pop, Sn 39.5. Scale bar is 50 µm.

packstone, wackestone, locally passing to packstone or *Globochaete–Saccocoma*/pelbiomicrite wackestone with synsedimentary erosion-supported intraclasts and extraclasts – SMF 2, 3, 4. *Globochaete alpina* and *Saccocoma* sp. are dominating over crinoids, bivalves, ostracods, aptychi, juvenile ammonites, calcified radiolarians, sponge spicules, crinoids, foraminifera tests, *Colomisphaera carpathica*, *Colomisphaera lapidosa*, *Colomisphaera cieszynica*, *Parastomiosphaera malmica*, *Stomiosphaera moluccana*, *Colomisphaera radiata*, *Committosphaera ornata*, *Committosphaera czestochowiensis*, *Cadosina semiradiata semiradiata*, *Cadosina semiradiata fusca* cysts, microgranular loricae of *Borziella slovenica*, *Carpathella rumanica*, *Chitinoidella boneti*, *Daciella danubica*, *Longicollaria insueta*, *Chitinoidella elongata*, *Chitinoidella hegarati*, *Chitinoidella carthagensis*, *Popiella oblongata* (Fig. 5). Some of bioclasts are phosphatized. Fractures in matrix and stylolites are filled by calcite impregnated by Fe-hydroxide.

Late Tithonian Praetintinnopsella Zone (Grandesso, 1977); Sn-19; 19.1; 19.2; 19.5; and Sn-19.8 samples

Reddish brown- and brown nodular limestone (locally with greenish grey nodules) with beds of fine-grained allodapic limestone. Biomicrite, bioturbated *Saccocoma*-radiolarian-*Globochaete* wackestone with nests composed of the *Saccocoma* packstone or biomicrite wackestone, *Globochaete–Saccocoma* packstone, pelbiomicrite *Globochaete–Saccocoma* crinoidal packstone, *Globochaete*– radiolarian wackestone belonging to SMF 3, 4 contain frequent *Globochaete alpina*, *Saccocoma* sp., locally also abundant calcified radiolarians, sponge spicules, rare ostracods, bivalves, aptychi *Laevaptychus* sp., crinoids, foraminifera test fragments (*Spirilina* sp., *Lenticulina* sp.), cysts of *Colomisphaera lapidosa*, *Colomisphaera cieszynica*, *Colomisphaera carpathica*, *Colomisphaera* sp., *Cadosina semiradiata semiradiata*, *Cadosina semiradiata fusca*, *Parastomiosphaera malmica*, loricae of *Praetintinnopsella andrusovi*, *Chitinoidella boneti*, *Chitinoidella hegarati*, *Chitinoidella popi*. Some bioclasts are silicified. Packstone is locally rich in clayey admixture and stylolites.

Late Tithonian Crassicollaria Zone, Remanei Subzone (Remane et al., 1986); Sn-20; 21.4; 21.5; 21.8; and Sn-22 samples

Reddish brown- and brown nodular limestones. Biomicrite wackestone or packstone of *Saccocoma–Globochaete* and radiolarian–*Sacco-*

coma–Globochaete microfacies locally with synsedimentary erosion-supported intraclasts were identified as belonging to SMF-3.

Globochaete alpina, *Saccocoma* sp. and calcified radiolarians dominate over fragments of ostracods, bivalves, aptychi, juvenile ammonites, crinoids, foraminifera, cysts of *Colomisphaera lapidosa, Colomisphaera carpathica* and over rare first fully hyaline loricae of *Tintinnopsella remanei*, *Calpionella alpina, Crassicollaria intermedia* and last *Praetintinnopsella andrusovi*. The matrix is slightly recrystallized.

Pieniny Limestone Formation (Birkenmajer, 1977)

Late Tithonian Crassicollaria Zone, Intermedia Subzone (Remane et al., 1986); Sn-21.8; 22.5; 23; 23.1; 23.5; 23.8; 24; and Sn-24.5 samples

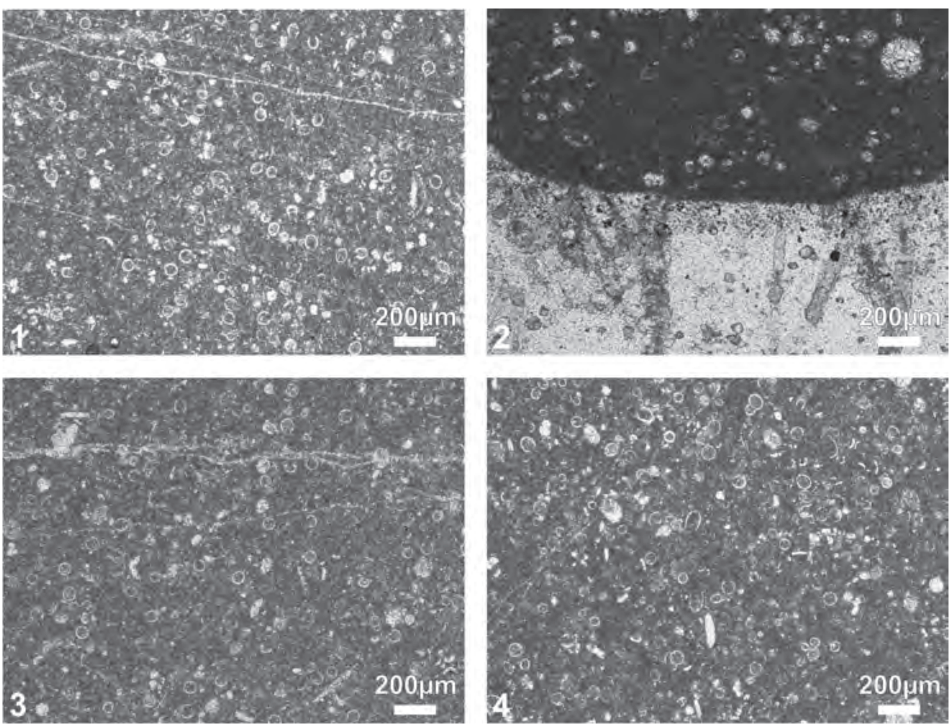


Fig. 6. Late Jurassic–Early Cretaceous microfacies in the Snežnica section: 1 – *Calpionella-Globochaete* wackestone of the Colomi Subzone, Crassicollaria Zone, Sample Sn 24; 2 – Chert layer in radiolarian–*Calpionella* wackestone – the onset of Alpina Subzone, Calpionella Zone; J/K boundary interval. Sample Sn 26.3; 3 – *Calpionella–Globochaete* wackestone – the onset of Alpina Subzone, Calpionella Zone; J/K boundary interval. Sample Sn 26.3; 4 – *Calpionella-Globochaete* wackestone of the Remaniella Subzone, Calpionella Zone. Sample Sn 36.5.

Reddish brown- and brown nodular and thin-bedded maiolica-type limestones. Biomicrite and bioturbated wackestone of *Calpionella-Globochaete* microfacies – SMF 3 (Fig. 6).

Planktonic crinoids *Saccocoma* sp. rapidly decrease in abundance. Bioclasts belong to *Globochaete alpina*, calcified radiolarians, fragments of bivalves, ostracods, aptychi, juvenile ammonites, foraminifera (*Spirillina* sp., *Lenticulina* sp.), fragments of agglutinated foraminifera (*Protomarsonella* sp.), cysts of *Colomisphaera lapidosa*, frequent loricae of *Crassicollaria intermedia*, *Crassicollaria massutiniana*, *Crassicollaria parvula*, *Calpionella alpina*, *Calpionella grandalpina*, *Calpionella elliptalpina*, rare *Tintinnopsella carpathica*. Matrix is locally penetrated by calcite-filled fractures and veins. Pyrite forms nest accumulations.

Late Tithonian Crassicollaria Zone, Colomi Subzone (Pop, 1994); Sn 25; 25.4; 25.8; and Sn-26 samples

Thin bedded maiolica limestone with dark-grey chert nodules. Biomicrite wackestone of *Calpionella–Globochaete* microfacies – SMF 3.

Bioclasts belong to *Globochaete alpina* spores, loricae of *Crassicollaria parvula* dominating over *Crassicollaria massutiniana*, *Calpionella grandalpina*, *Calpionella alpina* and *Tintinnopsella carpathica*, *Cadosina semiradiata semiradiata* cysts, fragments of ostracods, crinoid columnalia, aptychi, foraminifera (*Lenticulina* sp., *Spirillina* sp.). Some of bioclasts are impregnated by pyrite, some of them are phosphatized. *Crassicollaria colomi* was not observed, the Zone was determined on the base of rapid decrease of large *Calpionella* species and by C*rassicollaria parvula* predomination.

Early Berriasian Calpionella Zone, Alpina Subzone (*sensu* Pop, 1974; Remane et al., 1986) – followed by Reháková and Michalík, 1997; Lakova et al., 1999; Boughdiri et al., 2006; Andreini et al., 2007; Michalík and Reháková, 2011; Lakova and Petrova, 2013; López-Martínez et al., 2013, 2015; Guzhikov et al., 2012; Grabowski et al., 2010; Wimbledon et al., 2013; Grabowski et al., 2014; Hoedemaeker et al., 2016; Michalík et al., 2016; Svobodová and Košťák, 2016; Lakova et al., 2017; Wibmledon et al., 2017; Elbra et al., 2018a, b; Kowal-Kasprzyk and Reháková, 2019; Svobodová et al., 2019; Grabowski et al. (Grabowski et al., 2019) – **Sn – 26.3; 27; 27.6; 28; 28.3; 28.9; 29; 29.8; and Sn-30 samples.**

Pale, regularly thin bedded majolica type limestone with dark-grey chert nodules. Biomicrite wackestones of *Calpionella–Globochaete*–radiolarian microfacies – SMF 3, 4 (Figs. 6, 7). Small spherical forms of *Calpionella alpina* dominated over rare *Crassicollaria parvula* and *Tintinnopsella carpathica*. There are also common calcified radiolarians, *Globochaete alpina* spores, rare cysts of *Colomisphaera lapidosa*, *Stomiosphaerina proxima*, aptychi fragments, bivalves, ostracods, crinoids, ophiurids, foraminifera and sponge spicules. Some beds contain increasing amount of resedimented bioclasts, calpionellids like *Calpionella grandalpina*, *Calpionella elliptalpina*, *Crassicollaria massutiniana*, cysts *Cadosina semiradiata semiradiata*, *Cadosina semiradiata fusca*, *Colomisphaera fortis* and *Saccocoma* sp. Deformations of calpionelid loricae have been observed. Matrix is locally penetrated by frequent fractures and veins filled by calcite.

Early Berriasian Calpionella Zone, Ferasini Subzone (Pop, 1994); Sn-30,5; 31; 31.5; 32; 32.5; 33; 33.5; 34; 34.5; 35; 35.5; 36; 36.5; 36.5; and Sn-37 samples

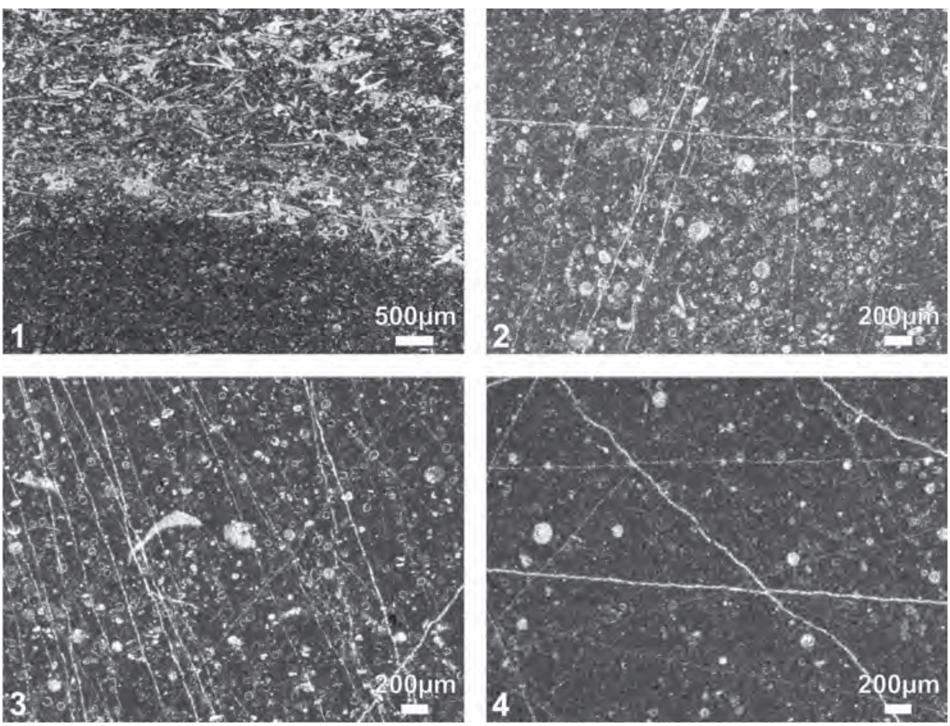


Fig. 7. Late Jurassic–Early Cretaceous microfacies in the Snežnica section: 1 – Laminated *Saccocoma-Globochaete* wackestone to packstone with rare calcified radiolarians. Sample Sn 14; 2 – Radiolarian-*Calpionella* wackestone of the Alpina Subzone, Calpionella Zone. Sample Sn 28; 3 – Radiolarian-*Calpionella* wackestone of the Alpina Subzone, Calpionella Zone. Sample Sn 29; 4 – *Calpionella*-radiolarian wackestone of the Elliptica Subzone, Calpionella Zone. Sample Sn 44.

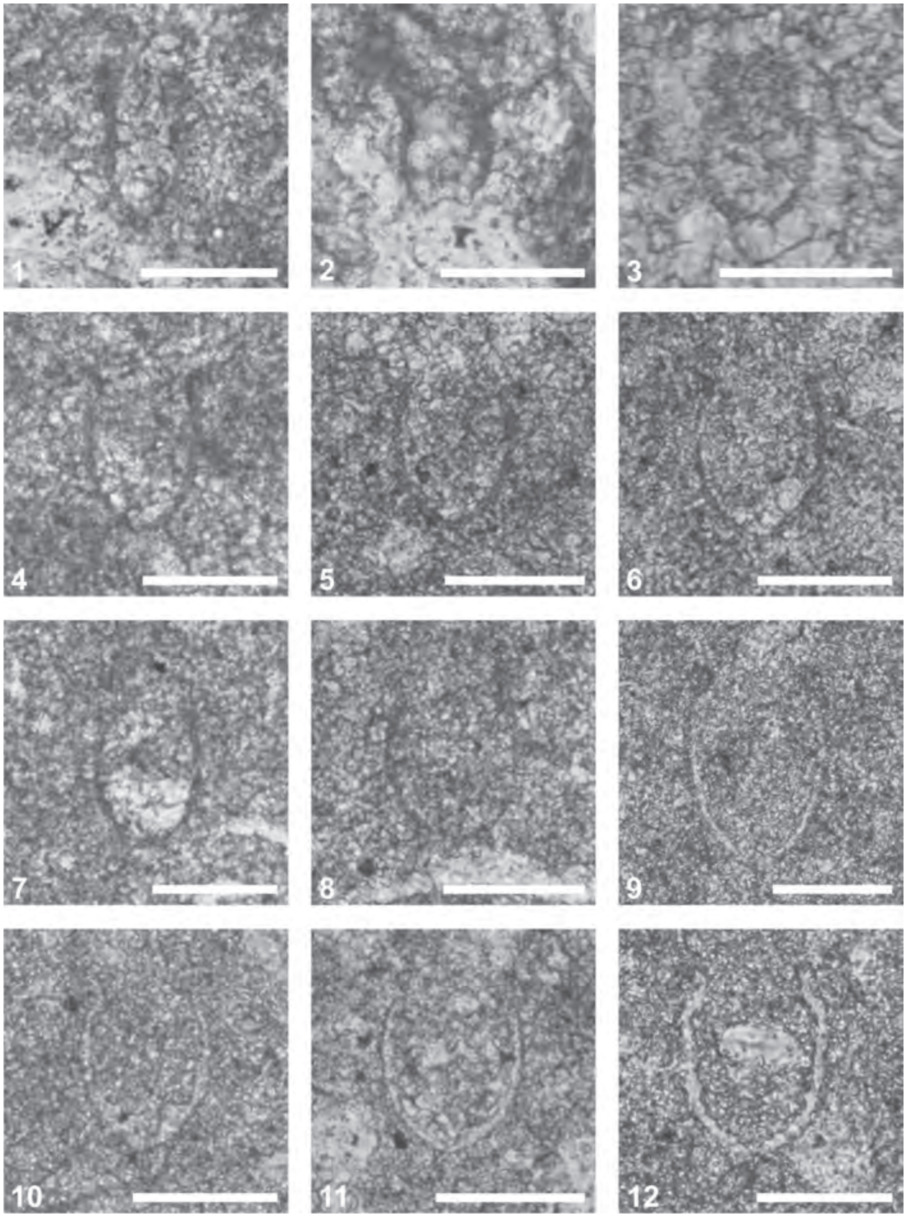


Fig. 8. Uppermost Early to Late Tithonian chitinoidellids and calpionellids from the Snežnica section: 1 – *Longicollaria dobeni* (Borza), Sn 18; 2 – *Borziella slovenica* (Borza), Sn 18.1; 3 – *Dobeniella cubensis* (Furrazola-Bermúdez), Sn 18.1; 4 – *Chitinoidella boneti* Doben, Sn 20.5; 5 – *Chitinoidella hegarati* Sallouhi, Boughdiri and Cordey, Sn 21; 6 – *Chitinoidella popi* Sallouhi, Boughdiri and Cordey, Sn 21; 7 – 8 – *Longicollaria insueta* Řehánek, Sn 20.5; 9 – 10 – *Praetintinnopsella andrusovi* Borza, Sn 21; Sn 21.4; 11 – *Tintinnopsella remanei* Borza, Sn 21.4; 12 – *Crassicollaria* aff. *intermedia* (Durand-Delga), Sn 21.4. Scale bar is 50 μm.

Pale, regularly thin bedded majolica type limestone with dark-grey chert nodules and stratiform chert layers. Biomicrite wackestone of *Calpionella-Globochaete*-radiolarian microfacies and bioturbated wackestone *Calpionella*- radiolarian microfacies – SMF 3 (Fig. 7).

Calpionella alpina together with *Globochaete alpina* and calcified radiolarians dominated. They are accompanied by fragments of bivalves, crinoids, ophiurioids, aptychi, foraminifera, calpionellids - Remaniella ferasini, *Remaniella catalanoi*, *Remaniella duranddelgai*, *Remaniella colomi, Lorenziella hungarica, Lorenziella plicata, Crassicollaria parvula, Tintinnopsella carpathica* (Fig. 8), cysts of *Colomisphaera lapidosa*, *Stomiosphaerina proxima*, *Cadosina semiradiata fusca*, *Cadosina semiradiata semiradiata*. At the base of the Zone in sample Sn-30.5, few Tithonian calpionellid species and few of *Saccocoma* sp. fragments were documented. At the end of this Subzone, morphologically variegated *Calpionella* species (*Calpionella* sp.) appear. Matrix is penetrated by frequent thin fractures filled by calcite.

Middle Berriasian Calpionella Zone, Elliptica Subzone (Pop, 1974); samples Sn 37.5; 38; 38.5; 39; 39.5; 40; 40.5; 41; 41.5; 42; 42.5; 43; 43.5; 44; 44.5; 45; 45.5; 46; 46.5; 47; 47.5; 48; 48.5; 49; 49.5

Pale, regularly thin bedded majolica type limestone with dark-grey chert nodules and stratiform chert layers. Biomicrite wackestone of *Calpionella*- radiolarian microfacies – SMF 3. Calpionellids and calcified radiolarians prevail in the microfacies. *Calpionella alpina*, *Calpionella elliptica*, *Calpionella minuta*, *Calpionella* sp., *Crassicollaria parvula*, *Tintinnopsella carpathica*, *Tintinnopsella doliphormis*, *Lorenziella hungarica*, *Lorenziella plicata*, *Remaniella ferasini*, *Remaniella catalanoi*, *Remaniella duranddelgai*, *Remaniella colomi*, *Remaniella cadischiana*, *Remaniella borzai*, *Remaniella filipescui*, cysts of *Colomisphaera lapidosa*, *Colomisphaera carpathica*, *Stomiosphaera moluccana*, *Stomiosphaera wanneri*, *Stomiosphaera* sp., *Cadosina semiradiata fusca*, calcite walled foraminifera – *Spirillina* sp., *Lenticulina* sp., *Nodosaria* sp., *Patelina subcretacea*, fragments of agglutinated foraminifera, infrequent fragments of bivalves, echinoids, crinoids, aptychi, ostracods, and ophiuroids were determined. Up to Sn-40 sample, *Calpionella* species slowly decreases in abundance. Some of loricae are deformed. Matrix is penetrated by net of fractures filled by calcite, larger accumulations of pyrite were also observed; in some cases pyrite impregnated bioclasts.

The study of younger limestone sequences was also started at the Snežnica Quarry. Already the first results of the research confirmed the fact that tectonics played an important role in this locality. This is reflected not only in the way in which allochems are preserved in thin sections, but mainly in the storage conditions of the studied limestones, confirmed by index fossils.

The studied sediments are represented by biomicrites (wackestone/ locally packstone). Radiolarian-calpionellid, respectively calpionellid-radiolarian, rarely radiolarian-calpionellid-dinoflagellate microfacies occur. Dominant allochems are irregularly arranged, sometimes more or less directed. Several redeposits and deformations of calpionellid loricae can be observed.

Calpionellopsis Zone with the Simplex, Oblonga and ?Murgeanui subzones and the Calpionellites Zone, Darderi Subzone were identified.

Calcareous nannofossils and nannofossil zonation

Nannofossils taxonomy follows Casellato (2010) and Nannotax website (Young et al., 2018). Biostratigraphic data and chronostratigraphic correlations are interpreted applying Casellato (2010) NJT and NKT zones and NK zones by Bralower et al. (1989). Calcareous nannofossils were present in all samples (Tab. 1). Their abundance and preservation are highly dependent on lithology. Nodular limestones of the Ammonitico Rosso facies, Czorsztyn Limestone Formation, provide poor and fragmented nannofossils (abundance 1-3-5 specimens per 10 fields of view of microscope) with relative higher species diversity. Biomicritic limestones of the Pieniny Limestone Formation contain extremely poor nannofossils (abundance about 1 specimen per 10 – 20 fields of views of microscope). Genera *Watznaueria* and *Cyclagelosphaera* quantitatively prevail over others making about 90 – 95 % of assemblage. This phenomenon probably indicate strong nannofossil modification during diagenesis (?nannofossil dissolution – Roth and Krumbach, 1986). Assemblages do not reflect the original calcareous nannoflora spectra. Marker species are recorded very rare. Most nannoconids are difficult to identify. Specimens of genus *Nannoconus* sp. or their fragments are observed from 12.4 m onwards (Fig. 9).

Rare occurrences of nannofossils in the lowermost part of section do not allow some more precise biostratigraphic interpretations. Fragments

Tab. 1.

Distribution of stratigraphically significant calcareous nannofossils and biostratigraphic correlation. Main events are highlighted in grey, secondary events or events subjected to further investigations are in white. Nannofossil events are mostly according to Casellato (2010). In brown – nodular limestones of the Ammonitico Roso facies, Czorsztyn Limestone Formation. In blue – biomicritic limestones of the Pieniny Limestone Formation. R = rare (8 – 6 specimens in slide), VR = very rare (5 – 3 specimens in slide), ER = extremely rare (1 – 2 specimens in slide), cf. = confer, ? = questionable, f = fragment.

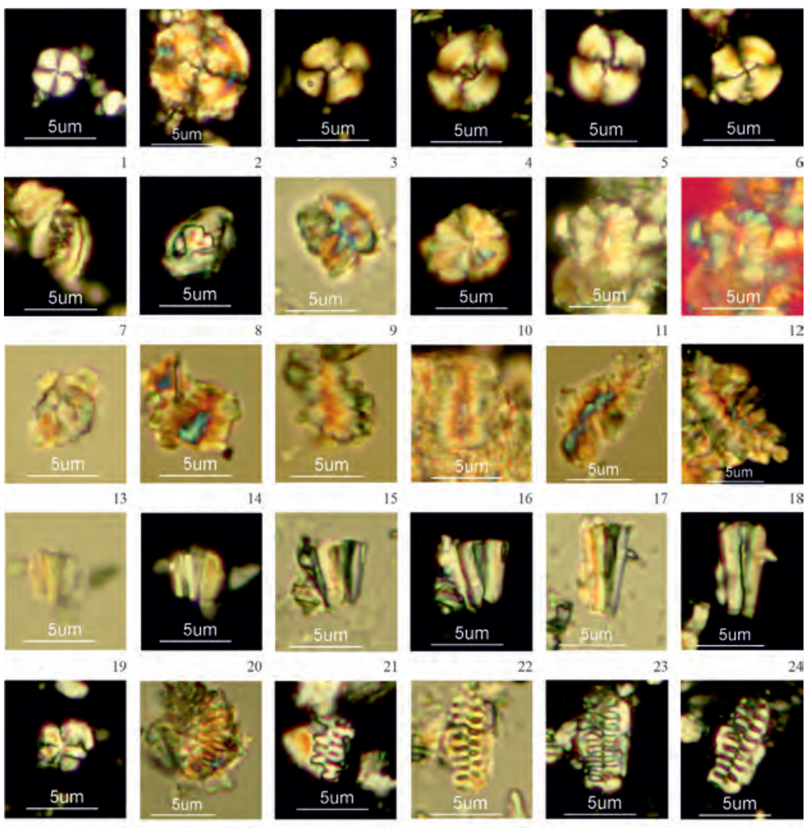


Fig. 9. Calcareous nannofossils in the Snežnica section. Cross-polarized light, figures 9, 13 – 17, 19, 21, 23, and 28 in plane-polarized light, figure 12 in gypsum plate. 1 – *Cyclagelosphaera margerelii*, 28.0 m; 2 – *Cyclagelosphaera argoensis*, 43.1 m; 3 – *Watznaueria communis*, 37.3 m; 4 – *Watznaueria britannica*, 40.4 m; 5 – *Watznaueria cynthae*, 31.4 m; 6 – *Watznaueria barnesiae*, 35.0 m; 7 – *Umbria granulosa granulosa*, 40.6 m; 8 – *Zeugrhabdotus cooperi*, 17.0 m; 9 – *Nannoconus compressus*, 15.2 m; 10 – *Nannoconus* sp., 26.5 m; 11, 12 – *Nannoconus erbae*, 25.9 m; 13 – *Nannoconus globulus minor*, 24.3 m; 14 – *Nannoconus* cf. *wintereri*, 40.4 m; 15 – *Nannoconus steinmannii minor*, 37.3 m; 16 – *Nannoconus kamptneri minor*, 40.4 m; 17, 18 – *Nannoconus steinmannii steinmannii*, 17 – 39.6m, 18 – 41.6 m; 19 – 22 – *Conusphaera mexicana minor*, 19, 20 – 35.1 m; 21, 22 – 35.0 m; 23, 24 – *Conusphaera mexicana mexicana*, 15.2 m; 25 – *Polycostella beckmannii,* 13.1 m; 26 – *Favioconus* cf. *multicolumnatus*, 10.0 m; 27 – 30 – *Favioconus multicolumnatus*; 27 – 10.0 m; 28 – 30 – 11.1 m.

Stage	Substage	Sněžnica	Bralower et al. (1989)* Casellato 2010	Sample No.	*Favioconus multicolumnatus*	*Conusphaera mexicana minor*	*Cyclagelosphaera argoensis*	*Polycostella beckmannii*	*Nannoconus* sp.	*Conusphaera mexicana mexicana*	*Nannoconus compressus*	*Zeugrhabdotus cooperi*	*Nannoconus globulus minor*	*Watznaueria cynthae*	*Zeugrhabdotus embergerii*	*Nannoconus erbeae*	*Nannoconus wintereri*	*Nannoconus globulus globulus*	*Retacapsa surirella*	*Nannoconus kamptneri minor*	*Nannoconus steinmannii minor*	*Umbria granulosa granulosa*	*Nannoconus steinmannii steinmannii*
				48,1 m											ER						ER		
				47,1 m			ER		ER				ER						ER	ER		ER	
				46,1 m					ER				ER							ER	ER		
				45,8 m top					VR	ER			ER			ER			ER	ER	ER		
				45,1 m base			ER									?					ER		ER
				44,7 m					ER														
			NK-1*	43,1 m			ER		VR	ER			VR							ER	ER		
				42,4 m																			
				41,6 m top			ER		VR	ER		ER	VR							ER	ER	f	ER
				41,0 m base					ER				ER	ER									
				40,6 m top					ER				ER							ER		ER	?
		Umbria granulosa granulosa		40,4 m base			ER						ER				f	ER		ER			ER
		FO *N. steinmannii steinmannii*		39,6 m			cf.		ER	?			ER							ER		fER	ER
				38,9 m									ER	ER						ER?			
				37,9 m top									ER										
Berriasian	Lower			37,3 m base			ER		ER				ER	ER				ER			ER		
		N. kamptneri/steinmanni minor		36,6 m top			ER		ER				ER					ER		ER?			
				36,1 m base					ER	ER			ER										
				35,0 m									ER	ER		ER							
				34,1 m			ER						ER										
				32,8 m			ER		ER	ER		ER	ER	?									
			NKT	32,5 m top					ER	VR			ER					ER					
				32,0 m base			f		ER	ER			ER			?							
				31,4 m					ER	ER			ER	ER									
				30,4 m top			f			ER													
				30,0 m base						VR													
				29,9 m top			ER			ER			ER			?f							
				29,0 m base			ER			R			ER										
				28,0 m																			
				27,8 m top			f			ER				ER									
		LO *P. beckmannii*		27,1 m base				ER	ER	R				ER									
		Retacapsa surirella		26,5 m top			ER		ER	ER			VR	ER				ER	ER				
		alpina acme	NJT17b	26,3 m base																			
		FO *N. wintereri*, *N. globulus globulus*		25,9 m top			ER						ER	ER		?	cf.						
	Upper	FO *W. cynthae*		25,6 m middle		ER	cf.			ER				ER	ER								
			NJT17a	25,2 m base				?	?		?		?										
		FO *N. globulus minor*		24,3 m top			?						?										
				24,0 m base			?			ER													
				23,9 m top					?	ER													
				23,0 m base		ER				VR													
				22,0 m						ER													
				21,0 m						ER													
		LO *F. multicolumnatus*		20,0 m	VR					VR													
Tithonian	Lower		NJT15b-16	19.00 m		ER	ER	VR		R		ER											
				18,0 m		ER		ER		VR													
		Z. cooperii		17,0 m		ER		VR	?	R		ER											
				16,0 m						ER													
		FO *C. mex. mex. s.s.*, *N. compressus*		15,2 m		ER				VR	ER												
				14,2 m	ER	ER	ER	R	ER														
		FO *P. beckmannii*, *C. mex. minor*		13,1 m	VR	ER	ER	R															
			NJT15a	11,9 m																			
		FO ?*C. mexicana minor*		11,1 m	VR	cf.																	
				10,0 m	VR																		
				9,6 m																			
			NJT14	8,0 m																			
				7,3 m																			
Kimmeridgian		FO *F. multicolumnatus*		6,0 m	ER	?																	
			?NJT14	5,0 m																			
		?*F. multicolumnatus* fragment		4,9 m	f?																		
				3,6 m																			
				2,0 m																			
				1,0 m																			

of *Favioconus multicolumnatus* found in 4.9 m and its whole specimens in 6.0 m indicate zone NJT14, Kimmeridgian. The NJT15a Subzone, Lower Tithonian is proved by the first occurrence (FO in the text) of *Conusphaera mexicana minor* in 11.1 m. The interval from the FO of *Polycostella beckmannii* in 13.1 m to the FO of *Nannoconus globulus minor* in 24.3 m, zones NJT15b and NJT16 is correlated with the upper lower Tithonian. The FO of *Nannoconus globulus minor* indicates the base of NJT17a zone, upper Tithonian. Fragment of the stratigraphically significant marker species *Nannoconus wintereri* in 25.9 m accompanied with *N. globulus globulus* allows the correlation with NJT17b zone, the uppermost Tithonian. Acme *Calpionella alpina*, Tithonian-Berriasian boundary respectively is detected in the overlying strata just over 26 m (Reháková in Michalík et al., 2021).

The last occurrence of *Polycostella beckmannii* in 27.1 m and the occurrences of *Nannoconus steinmanii/kamptneri minor* in 36.6 m and *Umbria granulosa grahulosa* in 39.6 m indicate zone NKT, the lowermost Berriasian. The FO of *Nannoconus steinmanii steinmanii* in 40.4 m defines the base of NK-1 zone, upper lower Berriasian.

Radiolarians and radiolarian zonation

We tried to isolate radiolarians from all samples in which radiolarians were detected in thin sections. Out of 13 samples, three were productive. The samples were first treated with 10 % acetic acid. Sample 28.9 revealed a poorly preserved radiolarian fauna, the residues of the other samples yielded rare sponge spicules and some of them also undeterminable structureless spheres, probably belonging to radiolarians. All samples were then processed with diluted 5 % hydrofluoric acid. Moderately well-preserved radiolarians were obtained from samples 14.00 and 44.50, whereas sample 28.9 and all other samples were devoid of determinable radiolarians. After each treatment we examined the etched rock fragments under a binocular microscope to check the occurrence of radiolarians. All radiolarians appearing in relief on the rock surface were found in limestone; no radiolarians could be extracted from chert nodules. The species inventory of the productive samples is listed in the Table 2 and illustrated in Figures 10 – 13.

Sample 14.00. A 7 cm thick bed of light gray laminated limestone with a 3 – 4 cm thick layer of gray vitreous chert in the middle part. Radiolarians are moderately well-preserved; nassellarians are much more abundant than spumellarians (Fig. 10). The assemblage contains several species characteristically appearing in the Tithonian, such as *Eucyrtidiellum pyramis* (Aita), *Cinguloturris cylindra* Kemkin and Rudenko, *Crococapsa*

Tab. 2. Occurrence of radiolarian species in the studied samples. The second column gives the zonal ranges of the species according to Baumgartner et al. (1995a). The zonal assignment according to Baumgartner et al. (1995a) and Matsuoka (1995) is shown in the bottom rows.

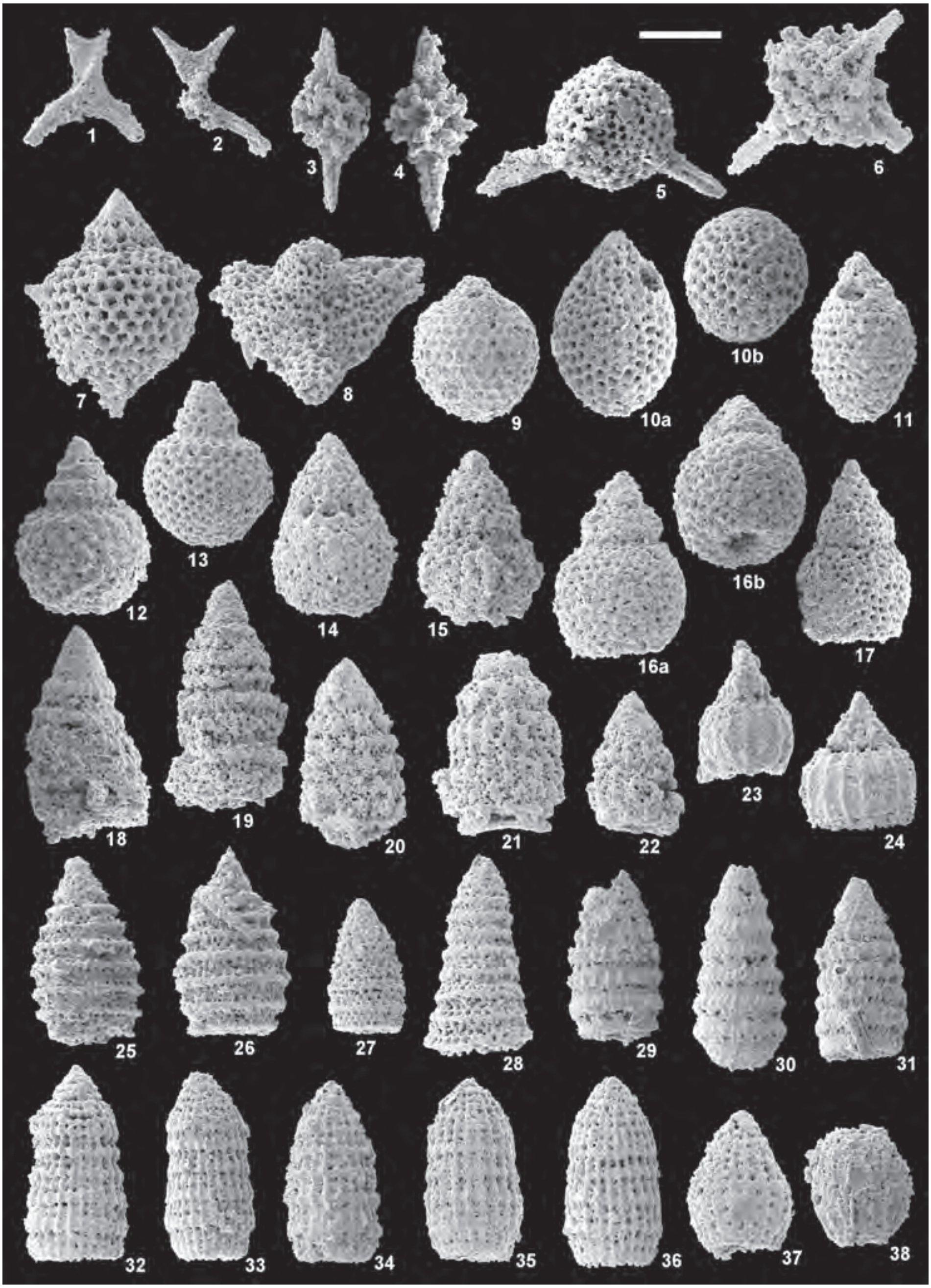
Radiolarian taxa **Samples**	**UAZ95**	**14.00**	**28.90**	**44.50**
Angulobracchia heteroporata Steiger				X
Angulobracchia mediopulvilla Steiger				X
Angulobracchia? portmanni Baumgartner	13–22			X
Arcanicapsa spp.			X	X
Archaeodictyomitra apiarium (Rüst)	8–22	X	X	X
Archaeospongoprunum patricki Jud	13–22			X
Cinguloturris cylindra Kemkin and Rudenko	12–17	X		
Crococapsa accincta (Steiger)		X		
Crococapsa pseudouterculus (Aita)		X	X	
Cryptamphorella dumitricai Schaaf		X		X
Deviatus diamphidius (Foreman)	8–14			X
Dicerosaturnalis gratiosus Dumitrica and Hungerbühler				X
Dicerosaturnalis trizonalis (Rüst)		X	X	X
Doliocapsa doliolum (Aita)		X		
Emiluvia chica Foreman	3–18	X		X
Eucyrtidiellum pyramis (Aita)	12–13	X		
Halesium palmatum Dumitrica				X
Hemicryptocapsa capita Tan	17–18		X	
Hemicryptocapsa carpathica (Dumitrica)	7–11			X
Hiscocapsa? altiforamina (Tumanda)	18–21			aff.
Hiscocapsa kaminogoensis (Aita)		cf.	cf.	
Hsuum raricostatum Jud	13–15		X	X
Mirifusus dianae (Karrer) s.l.	7–20			X
Neorelumbra buwaydahensis Kiessling		cf.		
Neorelumbra tippitae Kiessling		cf.		cf.
Obesacapsula cetia (Foreman)	10–17			X
Obesacapsula rusconensis Baumgartner	13–19		cf.	X
Obesacapsula verbana (Parona)	11–20		cf.	X
Pantanellium berriasianum Baumgartner	13–15	X		
Pantanellium squinaboli (Tan)	11–22	X	X	X
Parapodocapsa amphitreptera (Foreman)	9–18	X		
Parapodocapsa furcata Steiger	13–16		X	X
Praeparvicingula cosmoconica (Foreman)	13–22		X	X
Protunuma japonicus Matsuoka and Yao	7–12	cf.		
Pseudocrucella? elisabethae (Rüst)	13–22			X
Pseudodictyomitra carpatica (Lozyniak)	11–21	X		X
Pseudoeucyrtis? fusus Jud	13–17			X
Pseudoxitus gifuensis (Mizutani)	11–16		X	
Spinosicapsa aff. *coronata* Steiger *sensu* Baumgartner et al. (1995b)	11–20	X		X
Spinosicapsa milloti (Schaaf)	13–19			X
Spinosicapsa triacantha (Fischli)				X
Svinitzium depressum (Baumgartner)	13–18		cf.	cf.
Tethysetta boesii (Parona)	9–22	X		X
Thanarla patricki (Kocher)		X		
Triactoma kellumi Pessagno and Yang		X		
Tritrabs ewingi (Pessagno)	4–22			X
Xitus robustus Wu			X	
Zhamoidellum sp. A *sensu* Goričan (1994)		X	cf.	
AU Zones of Baumgartner et al. (1995a)		**12–13**	**13–15**	
Zones according to Matsuoka (1995)		***Pseudodictyomitra carpatica* Zone**		

accincta (Steiger), *Crococapsa pseudouterculus* (Aita), *Doliocapsa doliolum* (Aita), *Parapodocapsa amphitreptera* (Foreman) and *Pseudodictyomitra carpatica* (Lozyniak) (Aita and Okada, 1986; Steiger, 1992; Goričan, 1994; Hori, 1999). *Archaeodictyomitra apiarium* (Rüst) shows a wide intraspecific variability in this assemblage. In some specimens the intersegmental constrictions are well expressed (Fig. 10: 32–34) similarly to those of the ancestor species *Archaeodictyomitra minoensis* (Mizutani). In other specimens, the constrictions are much weaker (Fig. 10: 36). The broad age assignment to the Tithonian is evident even from genera alone – *Neorelumbra* first appears in the Early Tithonian and *Protunuma* last appears in the Late Tithonian (O'Dogherty et al., 2009).

Sample 28.90. White micrite with large irregularly shaped nodules of gray replacement chert. Radiolarians are rare and heavily corroded (Fig. 11). Only a few species could be determined with certainty and the diversity is reduced due to the poor preservation. The stratigraphically important species are *Hsuum raricostatum* Jud, *Parapodocapsa furcata* Steiger and *Praeparvicingula cosmoconica* (Foreman) that all first appear in the latest Tithonian (UA Zone 13 of Baumgartner et al., 1995a).

Sample 44.50. A 2.5 cm thick layer of dark gray replacement chert with gray micrite at margins. Radiolarians are moderately well-preserved (Figs. 11 – 12); spumellarians are more abundant and diverse than in the other samples. Large nassellarians such as *Obesacapsula* and *Mirifusus* are common. Pyritized specimens were also very rarely found; most of them belong to cryptocephalic nassellarians. In addition to *Hsuum raricostatum* Jud, *Parapodocapsa furcata* Steiger and *Praeparvicingula cosmoconica* (Foreman) present in sample 28.90 below, other species first appearing in

Fig. 10. Radiolarians from the Snežnica section, Sn-14: 1, 2 – *Dicerosaturnalis trizonalis* (Rüst); 3 – *Pantanellium squinaboli* (Tan); 4 – *Pantanellium berriasianum* Baumgartner; 5 – *Triactoma kellumi* Pessagno and Yang; 6 – *Emiluvia chica* Foreman; 7 – *Spinosicapsa* aff. *coronata* Steiger; 8 – *Parapodocapsa amphitreptera* (Foreman); 9 – Cryptamphorella *dumitricai* Schaaf; 10a – b, 11 – *Zhamoidellum* sp. A; 10a – b – lateral and antapical view of the same specimen; 12, 13 – *Crococapsa pseudouterculus* (Aita); 14 – *Crococapsa accincta* (Steiger); 15 – *Hiscocapsa* cf. *kaminogoensis* (Aita); 16a – b, 17 – *Doliocapsa doliolum* (Aita); 16a – b – lateral and antapical view of the same specimen.; 18 – *Cinguloturris cylindra* Kemkin and Rudenko; 19 – *Cinguloturris* sp.; 20 – *Xitus* sp.; 21 – *Neorelumbra* cf. *buwaydahensis* Kiessling; 22 – *Neorelumbra* cf. *tippitae* Kiessling; 23, 24 – *Eucyrtidiellum pyramis* (Aita); 25, 26 – *Tethysetta boesii* (Parona); 27, 28 – *Praeparvicingula* spp.; 29 – *Pseudodictyomitra carpatica* (Lozyniak); 30, 31 – *Pseudodictyomitra* spp.; 32 – 36 – *Archaeodictyomitra apiarium* (Rüst); 37 – *Thanarla patricki* (Kocher); 38 – *Protunuma* cf. *japonicus* Matsuoka and Yao. Magnification: Fig. 5; 125x (scale bar 120 μm); Figs. 1 – 4, 6 – 8, 18 – 22, 25 – 29, 31 – 36, 38: 150x (scale bar 100 μm); Figs. 9 – 17, 23 – 24, 30, 37: 200x (scale bar 75 μm).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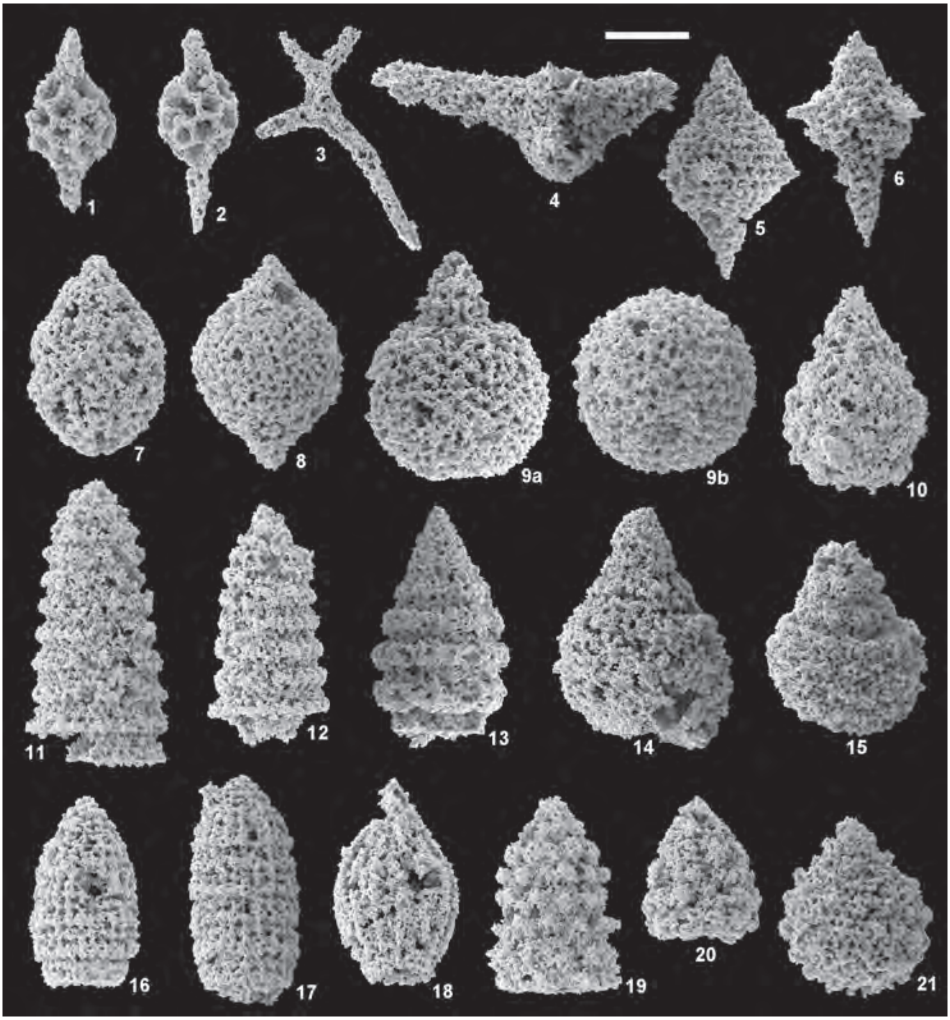


Fig. 11. Radiolarians from the Snežnica section, Sn-28.9: 1, 2 – *Pantanellium squinaboli* (Tan); 3 – *Dicerosaturnalis trizonalis* (Rüst); 4 – *Parapodocapsa furcata* Steiger; 5, 6 – *Spinosicapsa* spp.; 7 – *Zhamoidellum* sp.; 8 – *Hemicryptocapsa capita* Tan; 9a – b – *Crococapsa pseudouterculus* (Aita); lateral and antapical view of the same specimen; 10 – *Hiscocapsa* cf. *kaminogoensis* (Aita); 11, 12 – *Praeparvicingula cosmoconica* (Foreman); 13 – *Svinitzium* cf. *depressum* (Baumgartner); 14 – *Obesacapsula* cf. *verbana* (Parona); 15 – *Obesacapsula* cf. *rusconensis* Baumgartner; 16, 17 – *Archaeodictyomitra apiarium* (Rüst); 18 – *Hsuum raricostatum* Jud; 19 – *Xitus robustus* Wu; 20 – *Pseudoxitus gifuensis* (Mizutani); 21 – *Arcanicapsa* sp. Magnification: Fig. 15: 100x (scale bar 150 µm); Figs. 1 – 6,11 – 12, 14, 16 – 21: 150x (scale bar 100 µm); Figs. 7 – 10, 13: 200x (scale bar 75 µm).

the latest Tithonian UA Zone 13 of Baumgartner et al. (1995a) occur. These species are *Angulobracchia*? *portmanni* BAUMGARTNER, *Pseudocrucella*? *elisabethae* (RÜST), *Pseudoeucyrtis*? *fusus* JUD and *Spinosicapsa milloti* (SCHAAF); (Tab. 2).

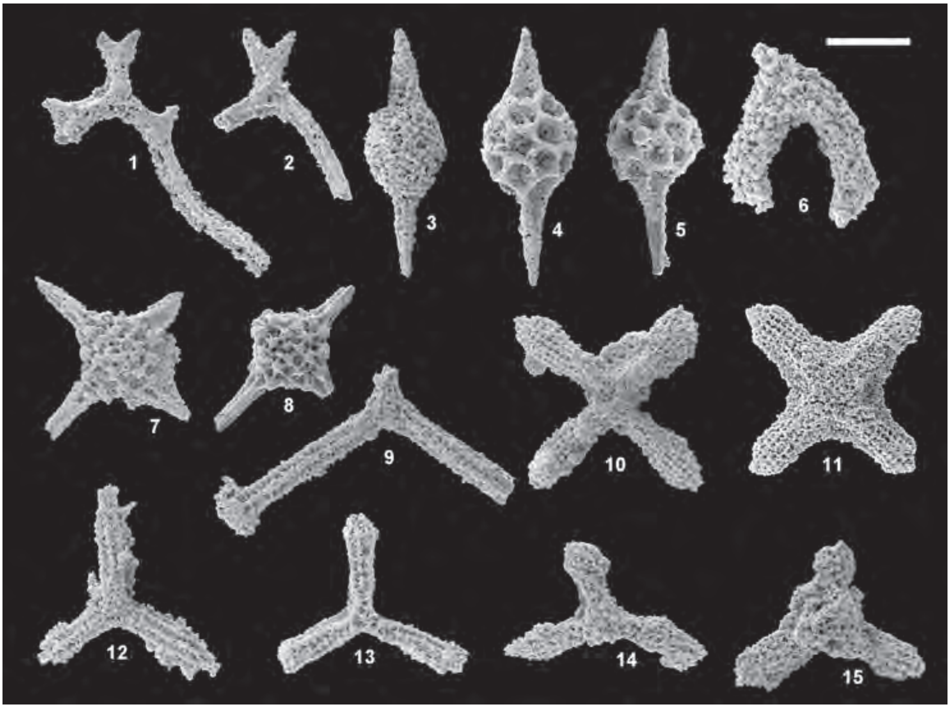


Fig. 12. Spumellarian radiolarians from the Snežnica section, Sn-44.5: 1 – *Dicerosaturnalis gratiosus* DUMITRICA and HUNGERBÜHLER; 2 – *Dicerosaturnalis trizonalis* (RÜST); 3 – *Archaeospongoprunum patricki* JUD; 4, 5 – *Pantanellium squinaboli* (TAN); 6 – *Deviatus diamphidius* (FOREMAN); 7, 8 – *Emiluvia chica* FOREMAN; 9 – *Tritrabs ewingi* (PESSAGNO); 10, 11 – *Pseudocrucella*? *elisabethae* (RÜST); 12 – *Halesium palmatum* DUMITRICA; 13 – *Angulobracchia heteroporata* STEIGER; 14 – *Angulobracchia*? *Portmanni* BAUMGARTNER; 15 – *Angulobracchia mediopulvilla* STEIGER. Magnification: Figs. 7 – 15: 100x (scale bar 150 μm); Figs. 1 – 6: 150x (scale bar 100 μm).

According to the zonation of Baumgartner et al. (1995a), the sample 14.00 is assigned to the UA Zones 12–13 as suggested by *Cinguloturris cylindra* KEMKIN and RUDENKO and *Eucyrtidiellum pyramis* (AITA) (Tab. 2). Samples 28.90 and 44.50 are assigned to the UA Zones 13–15 based on *Hsuum raricostatum* JUD and species mentioned above with FADs in the UA Zone 13. *Hemicryptocapsa carpathica* (DUMITRICA), occurring in sample 44.50 was, in the zonation of Baumgartner et al. (1995a) restricted to the Jurassic (see Tab. 2) but it was later found also in the Berriasian (Matsuoka, 1998). According to the zonation established by Matsuoka

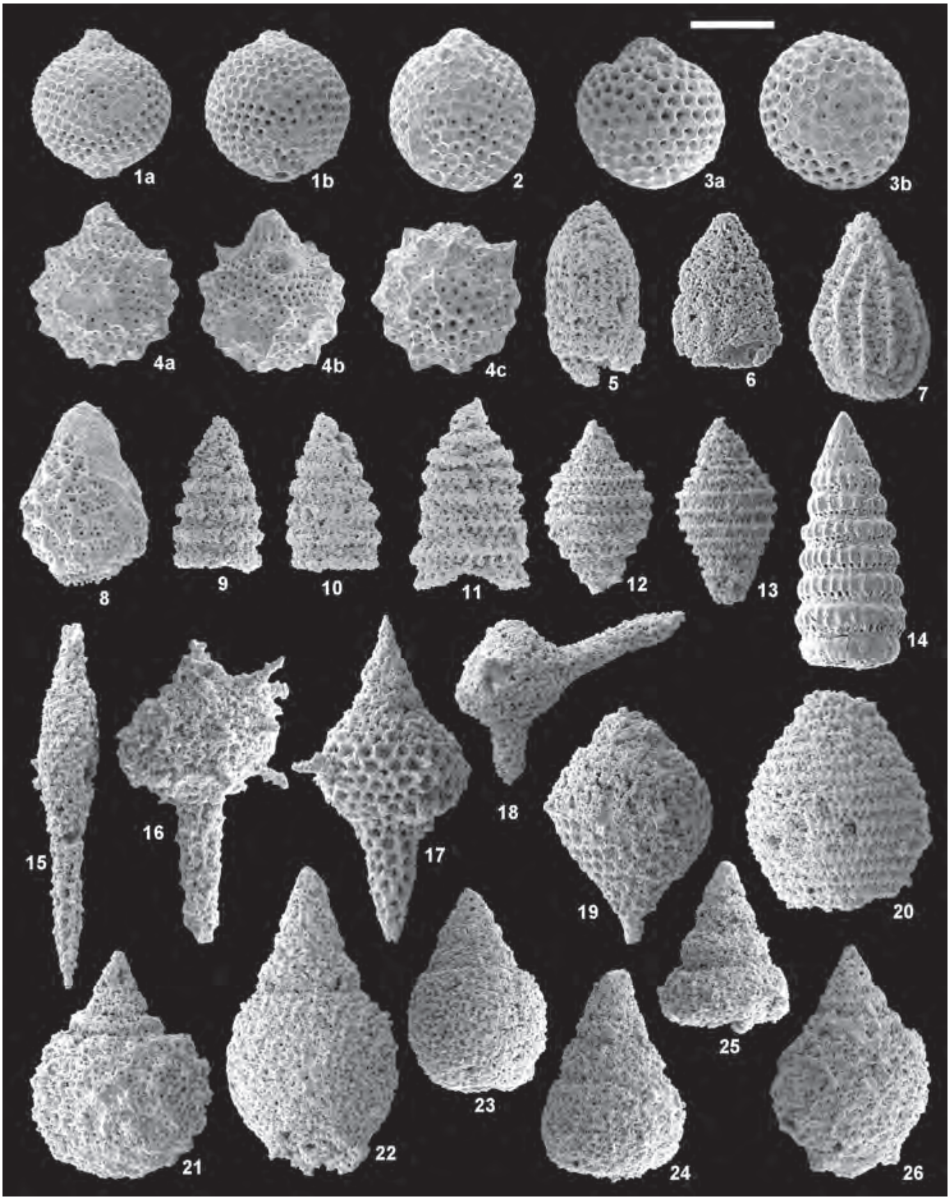
→

Fig. 13. Nassellarian radiolarians from the Snežnicasection sample Sn-44.5. 1a – b – *Hemicryptocapsa carpathica* (Dumitrica); 2, 3a – b – *Cryptamphorella dumitricai* Schaaf; 3a – b – lateral and antapical view of the same specimen; 4a – c – *Arcanicapsa* sp. Lateral (a), apical (b) and antapical view (c) of the same specimen; 5 – *Archaeodictyomitra apiarium* (Rüst); 6 – *Neorelumbra* cf. *tippitae* Kiessling; 7 – *Hsuum raricostatum* Jud; 8 – *Hiscocapsa*? aff. *altiforamina* (Tumanda); 9, 10 – *Svinitzium* cf. *Depressum* (Baumgartner); 11 – *Praeparvicingula cosmoconica* (Foreman); 12, 13 – *Tethysetta boesii* (Parona); 14 – *Pseudodictyomitra carpatica* (Lozyniak); 15 – *Pseudoeucyrtis*? *fusus* Jud; 16 – *Spinosicapsa milloti* (Schaaf); 17 – *Spinosicapsa triacantha* (Fischli); 18 – *Parapodocapsa furcata* Steiger; 19 – *Spinosicapsa* aff. *coronata* Steiger *sensu* Baumgartner et al. (1995b); 20 – *Mirifusus dianae* (Karrer) s.l.; 21 – *Obesacapsula cetia* (Foreman); 22 – 25 – *Obesacapsula verbana* (Parona); 26 – *Obesacapsula rusconensis* Baumgartner. Magnification: Figs. 12 – 13, 19 – 26: 100x (scale bar 150 µm); Figs. 5 – 7, 9 – 11, 14, 15 – 18: 150x (scale bar 100 µm); Figs. 2 – 4, 8, 14: 200x (scale bar 75 µm); Figs 1a – b: 250x (scale bar 60 µm). Specimens in figs. 1 – 4, 8 and 14 are pyritized.

(1995), all three samples belong to the rather long Pseudodictyomitra carpatica Zone. This zonal assignment is suggested by the presence of *Pseudodictyomitra carpatica* (Lozyniak) (Tab. 2) and the lack of *Cecrops septemporatus* (Parona), the evolutionary FAD of which defines the top of this zone. Here we note that radiolarian zonations available are rather rough across the Jurassic–Cretaceous boundary. A group of radiolarian researchers is currently working intensely on refining the precision of radiolarian dating in the Tithonian–Berriasian interval. Two objectives are followed – to include a great number of species in the future range chart (e.g. OʼDogherty et al., 2018) and to carry out high resolution sampling in key J–K boundary sections (e.g. Matsuoka et al., 2018).

Stable carbon and oxygen isotopes

Sequences of the Rosso Ammonitico and Maiolica facies are characterised with a “long term” carbon isotope trend without any CIE (carbon isotope excursions, see Michalík et al., 2009, 2016; Michalík & Reháková, 2011). Values of the $\delta^{13}C$ in the micrite matrix gradually decreased from values about + 3 ‰ in Late Oxfordian to values around +1 ‰ in Late Tithonian and this relatively stable values persisted during the whole Berriasian. In the Snežnica section (Fig. 14), $\delta^{13}C$ data ranged between +1.013 to + 2.040 ‰ (VPDB) confirming the $\delta^{13}C$ trend indicating decelerated sea water C-cycling (Weissert & Chanell, 1989; Price et al., 2016); they were documented in majority of sections on the Tethyan margin. Increase of the sea water temperature (approximately 2 – 4 °C)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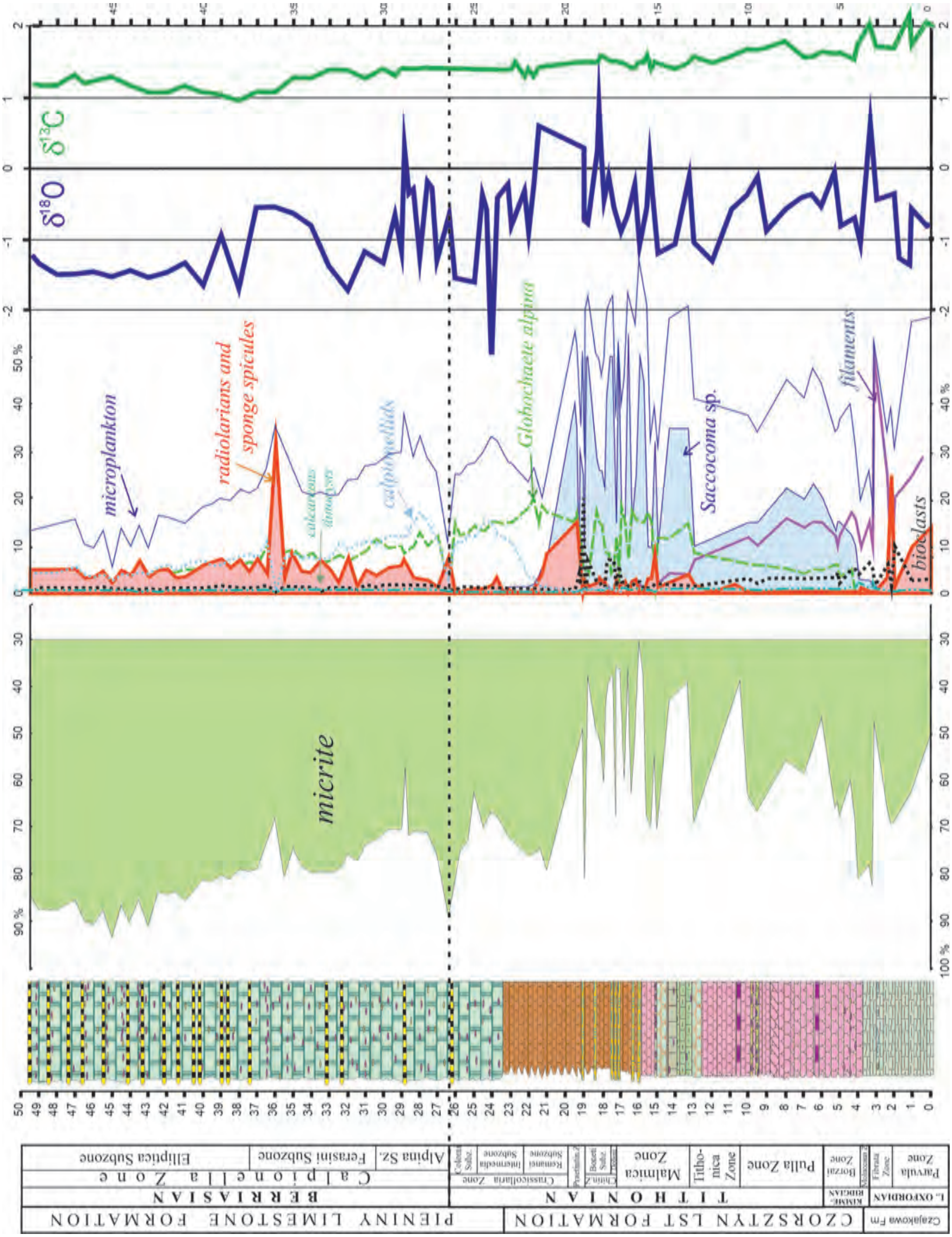
has been suggested on the base of the $\delta^{18}O$ trend in the J/K boundary interval in the Brodno and Strapkova sections (Michalík et al., 2009, 2016). However, these results from micrite matrix should be interpreted with a caution. Pelagic carbonate sediment largely derived from skeletons of planktonic organisms (e. i. nannofossils, calpionellids, etc.) and its original $\delta^{18}O$ content could be influenced by local conditions, especially by rate of precipitation and evaporitization of surface waters in the Early Berriasian arid climate. Wider range (in span –6 to + 1 ‰) and frequent changes of $\delta^{18}O$ values in the rock record seems to be the result of both sea-water salinity variations and short time sedimentary cycles during J/K boundary. The decrease of the $\delta^{18}O$ values from the Intermedia / Colomi boundary interval to the base of the Alpina Subzone indicates a warming trend. Large positive shifts of $\delta^{18}O$ values could reflect evaporation-related early diagenetic changes and short time eustatic fluctuations. Few short and one longer progressive increase of $\delta^{18}O$ values visible in the Alpina and Ferasini subzones may represent a slight cooling trend. Shifts of $\delta^{18}O$ composition could be also influenced by meteoric water in groundwater release from aquifers to basins during eustatic sea level drop (Price et al., 2016; Haq, 2014). The $\delta^{18}O$ distribution in the sections suggested that large lateral variation of water salinity/composition could be expected.

Fig. 14. Lithological column of the Snežnica sequence, quantitative representation of allochems in microfacies; calpionellid and cyst zonations and chemostratigraphy.


δ13C
δ18O
micrite
microplankton
radiolarians and sponge spicules
calcareous dinocysts
calpionellids
Globochaete alpina
Saccocoma sp.
filaments
bioclasts
PIENINY LIMESTONE FORMATION
CZORSZTYN LST FORMATION
Czajakowa Fm
BERRIASIAN
TITHONIAN
L. OXFORDIAN
Calpionella Zone
Elliptica Subzone
Ferasini Subzone
Alpina Sz.
Crassicollaria Zone
Remanei Subzone
Intermedia Subzone
Malmica Zone
Tithonica Zone
Pulla Zone
Borzai Zone
Fibrata Zone
Parvula Zone

References:

Aita, Y. & Okada, H., 1986: Radiolarians and calcareous nannofossils from the uppermost Jurassic and lower Cretaceous strata of Japan and Tethyan regions. *Micropaleontology,* 32, 2., 97–128.

Andreini, G., Caracuel, J. E. & Parisi, G., 2007: Calpionellid biostratigraphy of the Upper Tithonian – Upper Valanginian interval in Western Sicily (Italy). *Swiss J. Geosci.,* 100, 179–198.

Baumgartner, P. O., Bartolini, A., Carter, E. S., Conti, M., Cortese, G., Danelian, T., De Wever, P., Dumitrica, P., Dumitrica-Jud, R., Goričan, Š., Guex, J., Hull, D. M., Kito, N., Marcucci, M., Matsuoka, A., Murchey, B., O'Dogherty, L., Savary, J., Vishnevskaya, V., Widz, D. & Yao, A., 1995a: Middle Jurassic to Early Cretaceous radiolarian biochronology of Tethys based on Unitary Associations. In: Baumgartner, P. O., O'Dogherty, L., Goričan, Š., Urquhart, E., Pillevuit, A., De Wever, P. (Eds.): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology. *Mém.* Géol*. (Lausanne),* 23, 1013–1048.

Benzaggagh, M., Homberg, C., Schnyder, J. & Sonia Ben Abdesselam-Mahdaouid, S., 2015a: Description et biozonation des sections de crinoides saccocomidés du Jurassique supérieur (Oxfordien-Tithonien) du domaine téthysien occidental. *Ann. Paléont.,* 101, 95–117.

Birkenmajer, K., 1977: Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. *Stud. geol. pol.,* 45 1–158.

Borza, K., 1984: The Upper Jurassic – Lower Cretaceous parabiostratigraphic scale on the basis of Tintinninae, Cadosinidae, Stomiosphaeridae, Calcisphaerulidae and other microfossils from the West Carpathians. *Geol. Zbor. Geol. Carpath*., 35, 5, 539–550.

Boughdiri, M., Sallouhi, H., Maâlaoui, K., Soussi, M. & Cordey, F., 2006: Calpionellid zonation of the Jurassic – Cretaceous transition in north Atlasic Tunisia. Updated Upper Jurassic stratigraphy of the "Tunisian Trough" and regional correlations. *Comptes Rendus Geosci.,* 338, 1250–1259.

Bralower, T. J., Monechi, S. & Thierstein, H. R., 1989: Calcareous nannofossils zonation of the Jurassic-Cretaceous boundary interval and correlations with the Geomagnetic Polarity Timescale. *Mar. Micropaleont.,* 14, 153–235.

Casellato, C. E., 2010: Calcareous nannofossil biostratigraphy of Upper Callovian-Lower Berriasian successions from the Southern Alps, North Italy. *Riv. ital. Paleont. Stratigr.,* 16, 3, 357–404.

Dunham, R. J., 1962: Classification of carbonate rocks according to depositional texture. In: Ham, W. E. (Ed.): Classification of carbonate rocks*. Amet. Assoc. Petrol. Geol. Mem.,* 1, 108–121.

Elbra, T., Reháková, D., Schnabl, P., Čížková, K., Pruner, P., Kdýr, Š., Bubík, M., Svobodová, A. & Švábenická, L., 2018: Magneto- and biostratigraphy across the Jurassic-Cretaceous boundary in the Kurovice section, Western Carpathians, Czech Republic. *Cretaceous Res.,* 89, 211–223.

Elbra, T., Schnabl, P., Čížková, K., Pruner, P., Kdýr, Š., Grabowski, J., Reháková, D., Svobodová, A., Frau, C. & Wimbledon, W. A. P., 2018: Palaeo- and rock magnetic investigations across Jurassic-Cretaceous boundary at St Bertrand's Spring, Drôme, France – Applications to magnetostratigraphy. *Stud. Geophys. Geodaet.,* 62, 323–338.

Flügel, E., 2004: Microfacies of Carbonate Rocks. *Berlin, Springer-Verlag*, 976 pp.

Goričan, Š., 1994: Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mém.* Géol*. (Lausanne),* 18, 1–177.

Grabowski, J., Michalík, J., Pszczółkowski, A. & Lintnerová, O., 2010a: Magneto- and isotope stratigraphy around the Jurassic/Cretaceous boundary in the Vysoká Unit (Malé Karpaty Mountains): correlations and tectonic implications. *Geol. Carpath.,* 61, 309–326.
Grabowski, J., Haas, J., Márton, E. & Pszczółkowski, A., 2010b: Magneto- and biostratigraphy of the Jurassic/Cretaceous boundary in the Lókút section (Transdanubian range, Hungary). *Stud. Geophys. Geodaet.,* 54, 1–26.
Grabowski, J., Lakova, I., Schnabel, P., Sobień, K. & Petrova, S., 2014: Berriasian bio-and magnetostratigraphy and magnetic susceptibility of the Barlya section (Western Balkan Unit, Bulgaria) – preliminary results. *Vol. Jurassica,* 12, 1, 185–194.
Grabowski, J., Bakhmutov, V., Kdýr, S., Krobicki, M., Pruner, P., Reháková, D., Schnabl, P., Stoykova, K. & Wierzbowski, H., 2019: Integrated stratigraphy and palaeoenvironmental interpretation of the Upper Kimmeridgian to Lower Berriasian pelagic sequences of the Velykyi Kamienets section (Pieniny Klippen Belt, Ukraine). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* in press.
Guzhikov, A. Yu., Arkadiev, V. V., Baraboshkin, E. Yu., Bagaeva, I., Piskunov, V. K., Rudko, S. V., Perminov, V. A. & Manikin, A. G., 2012: New sedimentological, bio-, and magnetostratigraphic data on the Jurassic-Cretaceous boundary interval of Eastern Crimea /Feodosiya). *Stratigr. Geol. Correl.,* 20, 3, 261–294.
Grandesso, P., 1977: Gli strati a Precalpionellidi del Titoniano e I loro raporti con il Rosso Ammonitico Veneto. *Mem. Sci. Geol.,* 32, 1–15.
Haq, B. U., 2014: Cretaceous eustasy revisited. *Glob. Planet. Change,* 113, 44–58.
Hoedemaeker, J. P., Janssen, N. M. M., Casellato, C. E., Gardin, S., Reháková, D. & Jamrichová, M., 2016: Jurassic-Cretaceous boundary in the Río Argos succession (Caravaca, SE Spain). Integrated biostratigraphy of section Z along the Barranco de Tollo. *Rev. Paleobiol.,* 35,1, 111–247.
Hori, N., 1999: Latest Jurassic radiolarians from the northeastern part of the Torinoko Block, Yamizo Mountains, central Japan. *Sci. Reports Inst. Geosci., Univ. Tsukuba, Sec. B = Geol. Sci.,* 20, 47–114.
Kowal-Kasprzyk, J. & Reháková, D., 2019: A morphometric analysis of loricae of the genus *Calpionella* and its significance for the Jurassic/Cretaceous boundary interpretation. Newsletters 981 Stratigr. 52,1, 33–54.
Lakova, I. & Petrova, S., 2013: Towards a standard Tithonian to Valanginian calpionellid zonation of the Tethyan Realm. *Acta geol. pol.,* 63, 201–221.
Lakova, I., Stoykova, K. & Ivanova, D., 1999: Calpionellid, nannofossils and calcareous dinocyst bioevents and integrated biochronology of the Tithonian to Valanginian in the West Balkan Mountains, Bulgaria. *Geol. Carpath.,* 50, 151–168.
López-Martínez, R., Barragán, R., Reháková, D. & Cobiella-Reguera, J. L., 2013: Calpionellid distribution and microfacies across the Jurassic/Cretaceous boundary in western Cuba (Sierra de los Óreganos). *Geol. Carpath.,* 64, 3, 195–208.
López-Martínez, R., Barragán, R. & Reháková, D., 2015: Calpionellid biostratigraphy across the Jurassic/Cretaceous boundary in San José de Iturbide, Nuevo León, north-eastern Mexico. *Geol. Quart.,* 59, 581–592.
Matsuoka, A., 1995: Jurassic and Lower Cretaceous radiolarian zonation in Japan and in the western Pacific. *The Island Arc*, 4, 140–153.
Matsuoka, A., 1998: Faunal composition of earliest Cretaceous (Berriasian) radiolaria from the Mariana Trench in the western Pacific. *News Osaka Micropaleont.,* spec. vol., 11, 165–187.
Matsuoka, A., O’Dogherty, L., Goričan, Š., Baumgartner, P. O., Li, X., Chiari, M. & Bertinelli, A., 2018: Radiolarian phylogeny around the Jurassic–Cretaceous boundary and radiolarian

occurrences in the Bosso Valley section, central Italy. *JK2018 International Symposium, Abstract Vol., Mus. Hist. natur. Genève*, 58–59.
Michalík, J., Reháková, D., Halásová, E. & Lintnerová, O., 2009: The Brodno section – a potential regional stratotype of the Jurassic/Cretaceous boundary (Western Carpathians). *Geol. Carpath.,* 60, 3, 213–232.
Michalík, J. & Reháková, D., 2011: Possible markers of the Jurassic/Cretaceous boundary in the Mediterranean Tethys: A review and state of art. *Geosci. Frontiers,* 2, 4, 475–490.
Michalík, J., Reháková, D., Grabowski, J., Lintnerová, O., Svobodová, A., Schlögl, J., Sobień, K. & Schnabl, P., 2016: Stratigraphy, plankton communities, and magnetic proxies at the Jurassic/Cretaceous boundary in the Pieniny Klippen Belt (Western Carpathians, Slovakia). *Geol. Carpath.,* 67, 4, 303–328.
Michalík, J., Grabowski, J., Lintnerová, O., Reháková, D., Kdýr, S. & Schnabl, P., 2021: Jurassic and Cretaceous boundary record in Carpathian sedimentary sequences. *Cretaceous Res.,* 118, 104659. htpps://doi.org/10.1016/j.cretres.2020.104659.
Mojsisovics, E.bvon, 1867: Umgebung von Rogożnik und Czorsztyn. Nördliche Tatra-Thäler. *Verh.Geol. Reichsanst.,* 10, 212–214.
Nowak, W., 1976: *Parastomiosphaera malmica* (Borza) z Karpat polskich i jej znaczenie dla korelacji utworów dolnego tytonu. *Rocz. Pol. Tow. geol.,* 46 1–2, 89–134.
O'Dogherty, L., Carter, E. S., Dumitrica, P., Goričan, Š., De Wever, P., Bandini, A. N., Baumgartner, P. O. & Matsuoka, A., 2009: Catalogue of Mesozoic radiolarian genera. Part 2: Jurassic – Cretaceous. *Geodiversitas,* 31, 271–356.
O'Dogherty, L., Goričan, Š., Baumgartner, P. O., Matsuoka, A. & Chiari, M., 2018: Catalogue of Tithonian-Berriasian radiolarians. *JK2018 International Symposium, Abstr. Vol., Mus. Hist. natur. Genève*, 64–65.
Pop, G., 1974: Les zones des Calpionelles Tithonique-Valanginiens du silon de Resita (Carpates meridionales). *Rev. Roumaine Géol. Géophys. Géogr., sér. Géol.,* 18, 109–125.
Pop, G., 1994: Calpionellid evolutive events and their use in biostratigraphy. *Roman. J. Stratigr.,* 76, 7–24.
Price, G. D., Fözy, I. & Pálfy, J., 2016: Carbon cycle history through the Jurassic-Cretaceous boundary: A new global $\delta^{13}C$ stack. *Palaeogeogr. Palaeoclimatol. Palaeoecol*., 451, 46–61.
Reháková, D., 2000: Evolution and distribution of the Late Jurassic and Early Cretaceous calcareous dinoflagellates recorded in the Western Carpathians pelagic carbonate facies. *Miner. Slov.,* 32, 79–88.
Reháková, D. & Michalík, J., 1997: Evolution and distribution of calpionellids – the most characteristic constituents of Lower Cretaceous Tethyan microplankton. *Cretaceous Res.,* 18, 493–504.
Reháková, D. & Rožič, B., 2019: Calpionellid biostratigraphy and sedimentation of the Biancone limestone from the Rudnica Anticlinale (Sava Folds, eastern Slovenia). *Geologija,* 62, 1, 87 – 99. doi.org/10.5474/geologija.2019.004.
Remane, J., Borza, K., Nagy, I., Bakalova-Ivanova, D., Knauer, J., Pop, G. & Tardi-Filácz, E., 1986: Agreement on the subdivision of the standard calpionellid zones defined at the 2nd Planktonic Conference Roma 1970. *Acta geol. hung.,* 29, 5–14.
Roth, P. H. & Krumbach, K. R., 1986: Middle Cretaceous calcareous nannofossil biogeography and preservation in the Atlantic and Indian oceans: implications for palaeoceanography. *Mar. Micropaleont.,* 10, 235–266.
Steiger, T., 1992: Systematik, Stratigraphie und Palökologie der Radiolarien des Oberjura-Unterkreide-Grenzbereiches im Osterhorn-Tirolikum (Nördliche Kalkalpen, Salzburg und Bayern). *Zitteliana,* 19, 3–188.

Svobodová, A. & Košťák, M., 2016: Calcareous nannofossils of the Jurassic-Cretaceous boundary strata in the Puerto Escaño section (southern Spain) – biostratigraphy and palaeoecology. *Geol. Carpath.,* 67, 3, 223–238.

Weissert, H. & Channell, J. E. T., 1989: Tethyan carbonate carbon isotope stratigraphy across the Jurassic-Cretaceous boundary: an indicator of decelerated global carbon cycling? *Paleoceanography,* 4, 483–494.

Wilson, J. L., 1975: Carbonate facies in geologic history. *Berlin, Springer,* 471 pp.

Wimbledon, W. A. P., Reháková, D., Pszczółkowski, A. Casellato, C. E., Halásová, E., Frau, C., Bulot, L. G., Grabowski, J., Sobień, K., Pruner, P., Schnabl, P. & Čížková, K., 2013: An account of the bio- and magnetostratigraphy of the upper Tithonian – lower Berriasian interval at Le Chouet, Drôme (SE France). *Geol. Carpath.* 64, 6, 437–400.

Wimbledon,W. A. P., Reháková, D., Halásová, E., Lintnerová, O., Michalík, J., Pruner, P., Schnabl, P., Čížková, K., Košťák, M., Svobodová, A., Bulot, L. G., Frau, C., Bakhmutov, V., Grabowski, J., Wierzbowski, A., Pszczołkowski, A., Leanza, H., Riccardi, A., Vennari, V., Aguirre-Uretta, B., Tchoumatchenko, P., Stoykova, K., Ivanova, D., Sha, J., Li, G., Meizhen, C., Jianguo, L., Xiaoqiao, W., Riding, J., Hunt, C., Rawson, P., Copestake, P., Arnaud-Vanneau, A. M., Mohialdeen, I. J., Andreini, G., Parisi, G., Speranza, F., Satolli, S., Martinez, A. L. M., Barragan, R., Benzaggagh, M., Verreussel, R., Munsterman, D., Hoedemaeker, P., Vajda, V., Erba, E., Casellato, C., Bown, P., Pandey, K., Közy, I., Bardhan, S., Mojon, P. O., Sames, B., Lakova, I., Ivanov, M., Poulton, T. P., Galloway, J., Haggart, J. W., Davies, E. H., Alsen, P., Piacecki, S., Gardin, S., Galbrun, B., Ogg, J. G., Lucas-Clark, J., Pujana, I., Yondon, K. & Oloriz, F., 2017: The Tithonian / Berriasian stage boundary and the base of the Cretaceous System. *In: 10th International Symposium on the Cretaceous Vienna, August 21–26, 2017. Abstracts,* 290 p.

Young, J. R., Bown, P. R. & Lees, J. A., 2013: Nannotax3 website. (eds.) International Nannoplankton Association. 5 Febr. 2018. URL: http://ina.tmsoc.org/Nannotax3.

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CONFERENCE ABSTRACTS

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE HUTY FM FROM THE RK-1 BOREHOLE (RUŽOMBEROK, LIPTOV BASIN)

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The RK-1 borehole was sampled for providing a detailed nannofossil study of the 56 m thick sequence of the Huty Fm of the Central-Carpathian Paleogene Basin. The section has been studied with 49 samples. The abundance of the calcareous nannofossils were moderate (5 – 10 specimens in the 1 field of view) to low (1 – 5 specimens in the 1 field). The preservation of the calcareous nannofossils is moderate (mechanical damage and etching is visible on the minority of the specimens).

Calcareous nannofossils provide a high diversity. The assemblage comprises of reworked Mesozoic nannofossils, completed by Eocene, and Oligocene species. From a total number of 73 found taxa, altogether 40 species were autochthonous. The most common species were *Cyclicargolithus floridanus* (on average 34 %), *Coccolithus pelagicus* (on average 19 %), *Reticulofenestra umbilicus* (on average 10 %).

The nannoplankton species from the RK-section allow to determine the lower/middle Oligocene (Rupelian) age of the Huty Fm. They belong to the NP 22 – NP 23 Zones (*sensu* Martini, 1971; Young et al., 2017), which boundary was determined in depth of 31,5 m. Rupelian nannofossils comprise of species *Isthmolithus recurvus*, *Reticulofenestra ornata* and *Cyclicargolithus abisectus.* Their biozonation is based on the FO of species *Isthmolithus recurves* at the NP19/20 Zone, in the Eocene/Oligocene boundary, which disappear within NP 23 Zone. In the RK-1 section, this species occurs within the interval 45,8 – 16,5 m. The concurrent species *Reticulofenestra ornata,* which was recorded from 33,6 m, is considered as endemic nannofossils from the Zones NP 22 – 23. Younger species of *Cyclicargolithus abisectus* from the NP 23 Zone was found in the interval 31,5 – 18,5 m.

Paleoecological proxies of nannofossils from the Huty Fm in the RK-1 borehole were determined on the basis of the predominant species *Coccolithus pelagicus* and *Cyclicargolithus floridanus*, preferring temperate water condition (Aubry, 1992) and reticulofenestrids, *Cy. floridanus* preferring a eutrophic condition (Villa et al., 2008).

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References:

Aubry, M.-P., 1992: Late Paleogene calcareous nannoplankton evolution: a tale of climatic deterioration. In: Prothero, D. R., Berggren, W. A. (Eds.): Eocene-Oligocene Climatic and Biotic Evolution. Princeton, *Princeton University Press*, 272 – 309.

Martini, E., 1971: Standard Tertiary and Quaternary Calcareous Nannoplankton Zonation. Proceedings of the 2nd Planktonic Conference, Roma, 1970, 739 – 785.

Villa, G., Fioroni, C., Pea, L., Bohaty, S. M. & Persico, D., 2008: Middle Eocene-Late Oligocene Climate Variability: Calcareous Nannofossil Response at Kerguelen Plateau, Site 748. *Marine Micropaleont.*, 69, 173 – 192. http://dx.doi.org/10.1016/j.marmicro.2008.07.006.

Young, J. R., Bown, P. R. & Lees, J. A., 2017: Nannotax3 website. International Nannoplankton Association. Accessed 21 Apr. 2017. URL: https://www.mikrotax.org/Nannotax3.

BADENIAN/SARMATIAN BOUNDARY AND VARIATIONS OF FORAMINIFERAL ASSOCIATIONS OF VIENNA BASIN BASED ON THE BOREHOLE MZ 102

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Foraminifera have a great sensitivity to environmental changes and quick phylogenetic response. Their fossils are therefore used in paleoenvironment interpretation and biostratigraphic dating. The nutrient content, salinity, light, type of substrat and change of oxygen concentration in water at sedimental surface might play an important role in presence and distribution of benthic foraminifera.

The samples of this study come from the Borehole MZ 102, collected near Malacky (Western Slovakia) in the Záhorská nížina plain, which is a part of the Vienna Basin. The aims of the study are multiple: the paleoenvironmental interpretation of the western part of Vienna Basin during the middle Miocene, the determination of foraminiferal change at the Badenian/Sarmatian boundary and the determination of the relation between the foraminiferal morphogroups, ecologic factors and diversity. The studied borehole contains several sediment levels with a predominance of miliolids (family *Miliolidae*). The core sample consist mostly of fine-grained, pale to dark grey siltstones with intercalations of well sorted sandstones. Macrofauna was represented mostly by Bivalvia, Gastropoda shells and fish remains. The samples were collected every 10 cm from the borehole cores in Nafta, a. s., repository.

The foraminifera assemblages were determined into species and intergrade into morphological epiphytes groups (A, B, C and D) according to Langer (1988) and infauna according to Murray (2006). Percentual proportion of morphogroups was figured by the POLPAL program (Fig. 1). Studied part of the cores (74 samples) were characterized by specific foraminiferal associations and species. The core 6 and 5, in particular, contained planktonic foraminiferal species (i.e.: *Globigerina* sp., *Globorotalia* sp., *Turborotalia quinqueloba*) and especially *Tenuitella munda*. This last species allowed us to interpret these sediments as of the upper Badenian, acme – zone Tenuitellinata (Filipescu & Silye, 2008). Sarmat was determined from a sample at depth 1035.8 m based on the first occurrence of the Sarmatian species *Nodosaria dina*, *Elphidium hauerinum* and *Articularia articulinoides.* Strong paleoecological changes occured during the sedimentation. In the 1059.8 – 1041.60 m depth interval, a deep-water low-oxygen environment was determined by the presence of epiphytes-A, *Ammonia* and planktonic species (Langer, 1988; Murray, 2006). In the interval 1035.8 – 1034.6 m new foraminfera associations (*Nonion* sp. and *Cribroelphidium excavatum*) and epiphytes-C and epiphytes-D are present. This suggests a shallow, well-oxygenated environment that was algae-crated or by sea grass with enough light (Langer, 1988; Murray, 2006). At a depth of 659.4 m, we identified an associations of epiphytes-B (*Asterigerinata planorbis*, *Ammonia viennensis*, *Ammonia parkinsoniana*, *Aubignyna perlucida* and *Heterolepa dutemplei*) with a predominance of a planokonvex-shaped morpho group, which is advantageous during the addition turbulence and taxa adjusted to change of salinity. This may indicate fluctuations of income of the fresh water. We assume sedimentation in marginal sea energy environments (Langer, 1988; Murray, 2006). At 650.5 m in depth the associations of epiphytes-C (*Porosononion granosum*) with miliolids is suggesting a hypersaline environment (Murray, 2006). In the 649.2 – 646.1 m depth range, almost exclusively milliolid morphotypes were found, which are typical of sandy sediments of shallow bay areas. The temperature and salinity are also as the production of phytodetrite in the highest level. According to the analysis of diversity, such associations are common in the area of marginal sea to hypersaline lagoons (Langer, 1988; Murray, 2006).

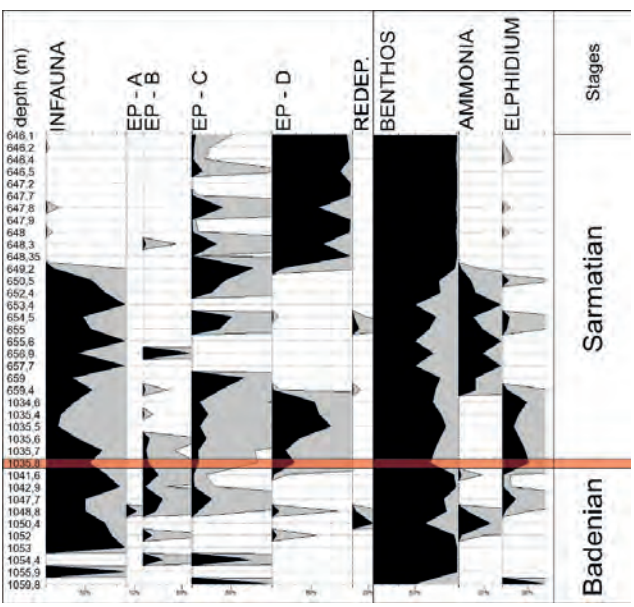

Fig. 1. Morphogroups abundance according to Langer (1988), infaunal abundance according to Murray (2006), redeposits, benthos and Ammonia – Elphidium abundance.

References:

Plašienková, I., 2016: Interpretácia zmien spoločenstiev dierkavcov na hranici Báden/Sarmat, na príklade vrtu MZ102 z Viedenskej panvy. Diplomová práca. Manuskript. Bratislava, Univerzita Komenského.

Murray, J. W., 2006: Ecology and Applications of Benthic Foraminifera. *New York, USA, Cambridge University Press,* p. 250.

Langer, M., 1988: Recent epiphytic foraminifera from Vulcano (Mediterranean Sea). *Rev. Paléobiol., Vol. spéc.,* 2, 827 – 832.

Filipescu, S. & Silye, L., 2008: New Paratethyan biozones of planktonic foraminifera described from the Middle Miocene of the Transylvanian Basin (Romania). *Geol. Carpath.*, 59, 6, 537 – 544.

DID THE OCEANIC ANOXIC EVENT 1D (LATE ALBIAN) AFFECT AGGLUTINATED FORAMINIFERAL ASSEMBLAGES IN DEEP-WATER ENVIRONMENT OF THE WESTERN TETHYS?

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High-resolution biostratigraphic studies using radiolarians, agglutinated foraminifers and chemostratigraphic analyses of stable carbon isotope data from flysch sediments of the Silesian Nappe (Outer Carpathians) allowed for the distinction a thin horizon of hemipelagic sediments enriched in black organic-rich shales (Alternans Level) corresponding to the oceanic anoxic event 1d (OAE1d; uppermost Albian). The sediments of the Alternans Level were deposited in marginal basin of the northern Western Tethys below CCD. For this reason, the hemipelagic non-calcareous claystones which separate the turbidite sequences contain only deep-water agglutinated foraminiferal (DWAF) assemblages, and are devoid of calcareous benthic and planktonic microfossils.

The DWAF associations of the uppermost Albian – lowermost Cenomanian succession (including the OAE1d horizon) were established on the basis of foraminiferal abundance and diversity using correspondence (CA), cluster and principal coordinate analyses (PCA). These analyses show that the changes in the DWAF assemblages along the section followed changes in facies pattern. They were related to accumulation of organic-rich sediments from one side, and appearance of long intervals with sedimentation of hemipelagic (green) claystones in more oxidized conditions.

Using the analysis of the DWAF morphogroups and foraminiferal abundance and taxonomic composition in relation to the characteristics of hemipelagic sediments (their colour and the TOC content), we indicated changes in the environmental conditions which took place during the OAE1d at the bottom of the basin. The variability of organic matter in black shales only slightly correlates with the abundance of the DWAFs and with their taxonomic composition. However, the latest Albian foraminiferal morphogroups display fluctuations along the Albian – Cenomanian

Boundary Interval reflecting the influence of two groups of factors: (i) oxygen concentration in bottom waters, *i.e.* low across the OAE1d, and (ii) the organic carbon flux that was linked to the onset of a massive redeposition of biogenic material from the European shelf. The last factor is related to the sea level fall during the 3-rd order regressive cycle.

EARLY MESOZOIC POSSIBLE ANCESTORS OF NEOGASTROPODA

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Neogastropoda is an extremely abundant group of carnivorous snails, most of which actively prey on a sea bottom. They constitute about one-third of all living gastropod species and are highly diverse today in tropics. Based on morphology group monophyly was confirmed also by molecular data, according to which neogastropods are in Hypsogastropoda and belong to “Siphonate” caenogastropods which also contain Tonnoidea, Stromboidea and Cypraeoidea as distant relatives. Tonnoidea is proposed as the closest sister group to Neogastropoda (Cuncha et al., 2009). According to newest classification order Neogastropoda includes 46 families split into 8 superfamilies and 11 families unassigned to superfamily (Bouchet et al., 2017). This classification differs significantly from the previous one (Bouchet & Rocroi, 2005) and indicates the dynamic development of researches on the group evolution and phylogenetic relationships within it.

The fossil record shows that nearly all modern neogastropod families have emerged in the Cretaceous. In the Late Cretaceous (Campanian – Maastrichtian) neogastropods are already ubiquitous worldwide, whereas in the older times they occur sparsely and majority of them are in need of a critical review. The oldest record of the true neogastropod is known from the Early Cretaceous (Valanginian) of Poland (Kaim, 2004) that supports the hypothesis of their Early Cretaceous origin. However, an insufficient number of the occurrences of the Early Cretaceous neogastropods (and earlier) is an obstacle in tracing their origin.

Three families – Purpurinidae, Maturifusidae and Pseudotritoniidae – were previously proposed as possible neogastropod stem groups. Currently there is some debate whether mostly Jurassic Maturifusidae are synonymous with mostly Triassic Pseudotritoniidae due to differences in the aperture morphology and teleoconch ornamentation. To clarify the relationship between Pseudotritoniidae and Maturifusidae a better knowledge of morphology, namely protoconch characteristics, of the type species of the genus *Pseudotritonium* – *P. venustus* (Münster, 1841) from the Cassian Formation (Ladinian – Carnian, Northern Italy) is required.

Family Maturifusidae is monogeneric and its species are widespread in the Jurassic of Europe. Family Pseudotritoniidae is also monogeneric with the type species described from the Upper Triassic of the Cassian Formation in Italy. Except for the type species, the Early Triassic *P. sciaphosterum* from the Moenkopi Formation of Utah, USA was assigned to this genus (Nützel, 2010). It is similar with *P. venustus* in teleoconch sculpture, but differs in shell outline and aperture shape and its protoconch is reminiscent recent Triphoroidea. Family members are rare and were described so far only from the Triassic of northern Italy and the USA (Utah).

The most diverse among possible neogastropod ancestors is family Purpurinidae. Previously almost 30 genera were assigned to it, most of them are classified to other higher taxa now. Currently, the family is composed of the following genera: *Angularia* Koken, 1892, *Cretadmete* Blagovetshenskiy & Shumilkin, 2006, *Khetella* Beisel, 1977, *Parangularia* Kutassy, 1934, *Pseudoscalites* Kittl, 1892, and *Purpurina* d'Orbigny, 1850. The attribution of *Ochetochilus* Cossmann, 1899 and *Werfenella* Nützel, 2005 remains disputable. The systematic position of *Gonioconcha* Bonarelli, 1921 remains uncertain because of poor preservation of the type material. Members of Purpurinidae were described from the Middle Triassic to Late Cretaceous from different regions of Eurasia.

The earliest members of Purpurinidae appeared in the Triassic as Pseudotritoniidae, while Maturifusidae members arose later, in the Early Jurassic. To trace their morphological changes in time and clarify possible phylogenetic relationships a further critical review of all members of these groups is required.

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References:

Bouchet, P. & Rocroi, J.-P., 2005: Classification and Nomenclator of Gastropod Families. *Malacologia*, 47, 1–2, 1–397.

Bouchet, P., Rocroi, J.-P., Hausdorf, B., Kaim, A., Kano, Y., Nützel, A., & Strong, E. E., 2017: Revised Classification, Nomenclator and Typification of Gastropod and Monoplacophoran Families. *Malacologia*, 61, 1–2, 1–526.

Cunha, R. L., Grande, C. & Zardoya, R., 2009: Neogastropod phylogenetic relationships based on entire mitochondrial genomes. *BMC Evol. Biol.*, 9, 210–10.

Kaim, A., 2004: The evolution of conch ontogeny in Mesozoic open sea gastropods. *Palaeont, pol.,* 62, 3–183.

Nützel, A., 2010: A review of the Triassic gastropod genus Kittliconcha Bonarelli, 1927 – implications for the phylogeny of Caenogastropoda. *Zitt. Reihe A: Mitt. Bayer. St.-Samml. Paläont. u. Geol.*, 50, 9–24.

DESCRIPTION OF THE CRANIAL ANATOMY OF AN EXCEPTIONALLY WELL-PRESERVED SKULL OF *SAUROPLEURA SCALARIS* (NECTRIDEA: UROCORDYLIDAE) FROM THE UPPER CARBONIFEROUS OF THE CZECH REPUBLIC USING MICRO-COMPUTED TOMOGRAPHY

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Nectrideans form a group of the Upper Carboniferous to the Upper Permian early tetrapods formerly referred to "lepospondyls". Phylogenetically, they may be divided into two major clades, Urocordylidae and unnamed group consisting of Scincosauridae + Diplocaulidae (Milner & Ruta, 2009). The first group consists of mostly Carboniferous and presumably fully aquatic forms with small limbs and long deep tails inferred for sinusoidal flexure during swimming. Despite this, no evidence of the lateral line system has been reported for the group (Bossy & Milner, 1998). Among urocordylids, *Sauropleura scalaris* from the Upper Carboniferous (Moscovian) of Nýřany (Czech Republic) is represented by relatively abundant skull material, but most of the cranial features are preserved only as imprints, and markedly compressed skulls often prevent from the preservation of a finer anatomical structures (e.g. braincase).

Here we report on a small, 14.5 mm long, articulated skull and mandible of *Sauropleura scalaris* with well-preserved dermal bones, and associated axial skeleton including almost complete tail region. The skull was for the first time scanned by the high-resolution micro-CT tomography (GE phoenix v|tome|x L240) and processed in the medical software ITK-SNAP v. 3.8.0. Consequently, the direct comparison of the morphology of ventral and dorsal surfaces of several dermal skull bones, as well as nature of their connections, is possible. In contrast to the previous skull reconstruction (Bossy & Milner, 1998), the specimen reported here suggests the jugal interrupts the connection between maxilla and quadratojugal. The later bone is also excluded from the posterior margin of skull by squamosal. Posteroventral part of the skull shows the first evidence of partially ossified braincase in *Sauropleura scalaris*. It consists of the opisthotic with conspicuous paroccipital process well corresponding to the morphology reported in other nectrideans, as well as possible exoccipital. With the skull length of only 14.5 mm, this indicates the neurocranium at least partially ossified at the relatively early stage of ontogeny. Labial surface of dentary bears a series of a few pits and elongated grooves, which represent the lateral line system of mandible. This is the first evidence of such a structure in Urocordylidae and adds to another support for a fully aquatic ecology inferred for the group. Additionally, almost complete tail region preserves the highest number of caudal vertebrae reported in *Sauropleura*, with estimated total count equal to or even higher than in long-tailed urocordylines.

References:

Bossy, K. A. & Milner, A. C., 1998: Order Nectridea Miall, 1875. In: Carroll, R. L., Bossy, K. A., Milner, A. C., Andrews, S. M. & Wellstead, C. F. (eds.): *Encyclopedia of Paleoherpetology, Part 1, Lepospondyli*. Munich, Verl. Dr. Friedrich Pfeil, 73–131.

Milner, A. C. & Ruta, M., 2009: A revision of *Scincosaurus* (Tetrapoda, Nectridea) from the Moscovian of Nýřany, Czech Republic, and the phylogeny and interrelationships of nectrideans. *Spec. Pap. Palaeont.,* 81, 71–89.

RECONSTRUCTION OF ENVIRONMENTAL CHANGE THROUGH THE RODENT DYNAMICS DURING THE LATE EARLY MIOCENE OF ANATOLIA

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Rodents are highly diverse in their ecology and can be found in almost every habitat. This makes them ideally suited for palaeoecological studies. Particularly, Miocene faunal changes in Europe have been well recorded and related to environmental shifts. European faunas that were dominated by glirid and eomyid at the beginning of the early Miocene shifted to cricetid dominated faunas at the end of the early Miocene. Concurrently, Anatolian localities were characterized by the presence of cricetid rodents that would appear in Europe only at the end of the early Miocene and beginning of the middle Miocene, such as *Cricetodon*, *Democricetodon*, *Megacricetodon* and *Eumyarion*. The latter genus is even dominant in the faunas from Anatolia. However, there had been very little study about the faunal changes in the early Miocene of Anatolia. Here, we explore the diversity dynamics of rodent assemblages from the early Miocene of Anatolia by determining shifts in their composition patterns and possible relationship with environmental change.

Our results on new localities from western Anatolia, and particularly the locality of Çapak, show a remarkable change in faunal composition in the late early Miocene rodent faunas. At the forefront of this change is the apparent decrease in the abundance of *Eumyarion* and its subsequent extirpation in Anatolian assemblages. By contrast, the proportions of *Democricetodon* and *Megacricetodon* increase notably. It is an indication of a drying trend. According to Van den Hoek Ostende et al. (2015) drying trend from the east may have been the cause behind the migrations from Anatolia to Europe. It is clear that, this trend in Anatolia preceded the migration into Europe of these cricetids.

It is, in fact, unlikely that such a trend affected the migration of Eumyarion, as this genus favours humid circumstances. As we know now, Çapak represents the last Anatolian occurrence before its extirpation in Anatolia. *Megacricetodon* and *Democricetodon*, on the other hand, seem to have favoured the dryer conditions at Çapak and may well have expanded their distribution as drier conditions also developed in Europe.

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References:

Hoek Ostende, L. W., van den, Mayda, S., Oliver, A., Madern, A., Hernández-Ballarín, V. & Peláez-Campomanes, P., 2015: Aliveri revisited, a biogeographical appraisal of the early Miocene mammals from the eastern Mediterranean. *Palaeobiodiver. Palaeoenviron.*, 95, 3, 271 – 284.

EARLY OLIGOCENE BRACHIOPOD FAUNA FROM THE ROCKY SHORE DEPOSITS AT MAMMENDORF, CENTRAL GERMANY

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The Lower Oligocene deposits from the large Mammendorf quarry, situated about 20 km NW of Magdeburg, Central Germany, that lie uncorformably on the Permian andesite, yielded numerous brachiopods. Rocky shore environments with boulder beds developed on the andesite in two Paleogene transgression cycles. Stratigraphically those deposits belong to the calcareous nannoplankton zones NP21 and NP22, corresponding with the Rupelian (Müller, 2011).

The brachiopod fauna comprises 13 species belonging to 11 genera. The short-looped terebratulide *Pliothyrina grandis* (Blumenbach, 1803) is the most common species (21.2 % of specimens), whereas megathyridid brachiopods are the most abundant and diverse group, constituting nearly 50 % of the material. Six species have been recognized: *Megathiris detruncata* (Gmelin, 1791), three species of *Argyrotheca*, i.e. *A. bitnerae* (Dulai, 2011) *A. lunula* (von Koenen, 1894) and *A. megalocephala* (Sandberger, 1862), *Bronnothyris rugosa* (Schreiber, 1871), and *Joania crenata* (Sandberger, 1862). Common are also inarticulate *Discinisca fallens* (Wood, 1874), cancellothyridid *Terebratulina tenuistriata* (Leymerie, 1846) and thecideide *Lacazella mediterranea* (Risso, 1826), while the remaining species, *Novocrania* sp., *Megerlia truncata* (Linnaeus, 1767), and *Platidia* sp. are very rare.

The Mammendorf brachiopod fauna is a combination of widespread species and species endemic to Central Germany. It displays a great affinity to the brachiopod assemblage from the Lower Oligocene of the Mainz Basin described by Sandberger (1862–1863), sharing with this fauna five genera and four species. Although having two species in common, in the species composition the Mammendorf assemblage differs strongly from that from the Late Eocene to Early Oligocene Silberberg Formation of Atzendorf (Bitner & Müller, 2015). The main difference between Atzendorf and Mammendorf is a total absence of megathyridids and the presence of two chlidonophorid species in the Atzendorf.

The stratigraphical range of the species *Discinisca fallens*, *Argyrotheca bitnerae* and *Megerlia truncata* is extended back to the Early Oligocene by their occurrence in Mammendorf assemblage.

References:

Bitner, M. A. & Müller, A., 2015: Brachiopods from the Silberberg Formation (Late Eocene to Early Oligocene) of Atzendorf, Central Germany. *Paläont. Z.,* 89, 673 – 688.

Müller, A., 2011: Der Steinbruch Mammendorf NW Magdeburg – ein Felslitoral der unteroligozänen Nordsee. *Geol. Sax.,* 57, 3 – 120.

Sandberger, C. L. F., 1862 – 1863: Die Conchylien des Mainzer Tertiärbeckens. Part 7: 233–270, pls 31 – 35 (1862), part 8: 271 – 468 (1863). *Wiesbaden, C.W. Kreidel's Verlag*.

EXCEPTIONAL FOSSIL RECORD OF THE MIDDLE MIOCENE MAMMALS FROM THE CZUJAN'S SANDPIT (MIKULOV, CZECH REPUBLIC)

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Czujan's sandpit represents significant terrestrial fossil site of the middle Miocene (~13,6 Ma, upper Badenian) vertebrates in Vienna Basin. The fossil site is no longer accessible and currently is part of the vineyard. During its existence (~40 years), it provided a hundreds of osteological and dental remains of terrestrial vertebrates which were deposited in the sands and gravels of distributory channel infills of the braid delta (Březina et al., 2021). All fossil remains identified so far belong to the Proboscidea, Rhinocerotidae, Chalicotheriidae, Equidae, Palaeomerycidae, Cervidae, Bovidae, Suidae, Amphicyonidae and Testudines (Jüttner, 1938; Thenius, 1951; Holec, 1985; Seitl, 1985; Březina et al., 2021). As for the fossil record, Czujan's sandpit is a unique locality because of the occurrence of some uncommon species such as cf. *Retroporcus matritensis* (Suidae), *Tethytragus stehlini* (Bovidae), *Testudo kalkburgensis* (Testudines) and *Zygolophodon turicensis* (Mammutidae). Moreover, species *Zygolophodon turicensis* and *Tethytragus stehlini* are much more abundant than other taxa from the Czujan's sandpit.

Unfortunately, the fossils from Czujan's sandpit lack any field documentation except for some sporadic information on the labels. Consequently, we are limited primarily to the date of collection and to the study of fossil material itself. Thanks to well-preserved (mineralized) bones with minimal wear, it is possible to study the anatomy of the animals in high detail. In total, nine types of the bone preservation have been identified. According to the remnants of sediments on the fossil bones, the state of preservation most probably differs depending on the petrographic features of the individual fluvial channel infill in which the bones were buried (silt, sand or gravel with clayey to sandy matrix). Bones with the same type of preservation usually have the same date of collection. When the new profiles in Czujan's sandpit were opened, the old extracted parts were already leveled (Březina, 2019). Hence, the observed characteristics well support the previous assumption of Březina et al. (2021) that some skeletal elements could have been preserved in anatomical connection in one channel infill. These observed characteristic of the fossil material from the Czujan's sandpit also indicates the existence of several fossiliferous channel infills that were excavated during mining from the 1930s to the 1970s.

A detailed osteological study of those taxa represented by more than 2 skeletal elements revealed the completeness of the skeletons. It is (from the most complete, including ribs and vertebrae) *Zygolophodon turicensis* (23 %), *Hoploaceratherium* sp. (11 %), *Brachypotherium brachypus* (8 %), Palaeomerycidae *indet.* (7 %), *Gomphotherium angustidens* (7 %), *Tethytragus stehlini* (4 %), and *Heteroprox larteti* (1,3 %). Mammutid *Zygolophodon turicensis* is known especially from the isolated teeth or rarely from complete lower or upper jaws. Therefore, the 25 % skeletal completeness (tusks, mandible, vertebrae, ribs, scapula, pelvis, all long bones, isolated carpals, tarsals, and metacarpals) of the *Zygolophodon turicensis* from Czujan's sandpit ranks this fossil site among the most important localities of this species worldwide.

References:

Březina, J., 2019: Neogenní savci z okolí Mikulova. *Acta Mus. Morav., Sci. geol.,* 104, 2, 217–239.

Březina, J., Alba, D., Ivanov, M., Hanáček, M. & Luján, Á. H., 2021: A middle Miocene vertebrate assemblage from the Czech part of the Vienna Basin: Implications for the paleoenvironments of the Central Paratethys. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 575, 110473, 1−17.

Holec, P., 1985: Finds of mastodon/Proboscidea, Mammalia/relics in Neogene and Quaternary sediments of Slovakia/ČSSR. *Západ. Karpaty, Sér. Paleont.,* 10, 13–53.

Jüttner, K., 1938: Das Neogen des unteren Thayalandes. *Verh. Geol. Bundesanst.,* 32, 201–224.

Thenius, E., 1951: *Gazella* cf. *deperdita* aus dem mitteleuropaischen Vindobonien und das Auftreten der Hipparionfauna. *Eclogae geol. Helv.,* 44, 381–394.

Seitl, L., 1985: Fauna mastodontů (Proboscidea, Mammalia) moravské části vídeňské pánve. *Čas. Morav. Mus.,* 70, 71–94.

EXPLORING THE PANNONIAN EULIPOTYPHLAN DIVERSITY OF SLOVAKIA: BIOSTRATIGRAPHICAL AND PALEOECOLOGICAL CONSIDERATIONS

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The European late Miocene (c.a. 11.5 Ma – 5.5 Ma) has undergone significant changes in its mammal diversity, affected by both environmental and biogeographical aspects. Among mammals, the local sensitivity to humidity changes of the eulipotyphlan fauna is likely able to reveal progressive environmental shifts or oscillations. For instance, since the specific abundance of Eulipotyphla is positively correlated to the degree of moisture (Furió et al., 2011), the high diversity observed in Central Europe seems environmental-driven and favored by the Pannonian Basin system. The evolution of such an area in terms of faunal dynamics and environmental stability became a frequent subject in the literature of the last decade (e.g. Daxner-Höck et al., 2016; Joniak et al., 2020) since it involves important biostratigraphic comparisons between Central and Western European localities. Considering the strategic position of Slovakia in the Northern part of the Pannonian Lake, the late Miocene Slovak eulipotyphlan fauna may constitute an important tool in the reconstruction of past ecosystems.

The MN9 locality of Borský Svätý Jur appears as a unique reference site since it contains in abundance species that reach Central Europe (e.g. "*Schizogalerix*" *voesendorfensis*, *Lantanotherium sanmigueli*), but not some common MN9 taxa (e.g. *Plesiodimylus*). Overall, this locality delivered material showing faunal similarities with Central and Westernmost MN9 fauna of Europe (e.g. Vösendorf, Nebelbergweg, Can Llobateres). An increase of diversity is observed in the relatively homogeneous MN9 faunas of Slovakia (Studienka), Austria (Richardhof-Golfplatz) and Hungary (Rudabanya), coinciding with the maximal extension of the Pannonian Lake (Magyar et al., 1999).

A peculiar faunal evolution is observed in Eastern Austria and Western Slovakia during the late Miocene. Firstly, variations of widely-spread species are recognized, such as *Dinosorex engesseri* in the MN9, implying the emergence of local lineages. In spite of this observation, unexpected differences are constated in faunal compositions since Slovak Eulipotyphla are less diverse and composed by a lesser abundance of water-dependent species. This holds particularly true for Talpidae, whose big-size species (e.g. *Talpa gilothi*, *Urotrichus giganteus*) are not recorded in the Danube Basin. In both Vienna (Eichkogel) and Danube Basins (Krásno), a turnover in faunal representation is noticed in the early MN11 with the sudden drop of eulipotyphla abundance and the growing success of ubiquitous species. The newly discovered MN12 Slovak locality of Šalgovce represents a next phase of this trend by its fauna almost exclusively constituted by Soricidae and ubiquitous species.

These preliminary results support previous studies considering the local and variable evolution of the northern Pannonian Basin system during the late Miocene (e.g. Magyar et al., 1999; Joniak et al., 2020) and the consequences of such heterogeneity on mammal communities. Even so, a similar evolutionary pattern is recognized in the Danube and Vienna Basins, suggesting both local and regional constraints.

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References:

Daxner-Höck, G., Harzhauser, M. & Göhlich, U. B., 2016: Fossil record and dynamics of Late Miocene small mammal faunas of the Vienna Basin and adjacent basins, Austria. *Comp. Rend. Palevol,* 15, 855 – 862.

Furió, M., Casanovas-Vilar, I. & van den Hoek Ostende, L. W., 2011: Predictable structure of Miocene insectivore (Lipotyphla) faunas in Western Europe along a latitudinal gradient. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 304, 219 – 229.

Joniak, P., Šujan, M., Fordinál, K., Braucher, R., Rybár, S., Kováčová, M., Kováč, M., Aumaître, G., Bourlès, D. L. & Keddadouche, K., 2020: The age and paleoenvironment of a late Miocene floodplain alongside Lake Pannon: Rodent and mollusk biostratigraphy coupled with authigenic 10Be/9Be dating in the northern Danube Basin of Slovakia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 538, 109 – 482.

Magyar, I., Geary, D. H. & Müller, P., 1999: Paleogeographic evolution of the late miocene Lake Pannon in Central Europe. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 147, 151 – 167.

THE QUICK AND THE DEAD. COMPETITION AS DRIVER FOR SHORTER LONGEVITIES

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Species are not equal in front of extinction. While mammals have shorter species duration than invertebrates (e.g. Stanley, 1975), variations have been observed within mammal orders (e.g. Flynn et al., 1995; Prothero et al., 2014), potentially related to phylogenetic and environmental factors (Smits, 2015). Among mammals, Rodentia are widely known as useful biostratigraphical markers, presumably because of the short life-span of some common taxa. Other small mammal orders, such as Lagomorpha and Eulipotyphla, are assumed to have longer species durations, but no comprehensive assessment of these durations have been made in literature. Here, we provide a preliminary assessment of small mammals longevity based on Paleogene and Neogene records extracted from the NOW database (The NOW Community, 2021).

Overall, there is a positive correlation between the number of occurrences and longevity in our data, which was an expected result. Nevertheless, this signal is disturbed by outliers with few occurrences and showing abnormal species duration. Such outliers are more commonly found in the North-American fossil record, suggesting taxonomic issues. A comparison of the longevities of the three small mammal orders confirms that Rodentia have the shortest median durations both for species (2.53 my) and genera (4.03 my), while the two other orders show longer longevities: Eulipotyphla have a shorter median duration of genera than the Lagomorpha (5.15 my vs. 5.75 my) while the latter has a longer median duration at the species level (3.85 my vs. 3.25 my).

Even though several outliers are recognized at the species (e.g. *Mesogaulus paniensis*), genus (e.g. *Centetodon*) and family levels (e.g. Geomyidae), a common pattern emerges in which groups with the largest diversity (e.g. Muridae, Soricidae) show the shortest median longevity. On the other hand, longer taxa durations are common in groups with low diversity. In those cases in which we find long-lived genera from the same family with similar ranges, these are often taxa at the edge of the spectrum in morphology (*Glis*, *Glirulus*), size (*Miopetaurista*, *Blackia*) or life-style (*Talpa*, *Desmanella*). This pattern suggests that competition is a driving factor in longevity. Interspecific competition in diverse and abundant groups lead to a high Red Queen dynamics, which results in a rapid sequence of chrono-species. Taxa that on the other hand have a niche of their own with little competition are capable of remaining relatively unaltered for a long period of time, provided that their niche remains available. Thus, apart from revealing possible taxonomic issues, the persistence of such long-lasting taxa in local fauna likely displays a relative stability of ecosystems.

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References:

Flynn, L. J., Barry, J. C., Morgan, M. E., Pilbeam, D., Jacobs, L. L. & Lindsay, E. H., 1995: Neogene Siwalik mammalian lineages: Species longevities, rates of change, and modes of speciation. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 115, 249 – 264.

Prothero, D. R., 2014: Species longevity in North American fossil mammals. *Integr. Zool.*, 9, 383 – 393.

The NOW Community, 2021: New and Old Worlds Database of Fossil Mammals (NOW). Licensed under CC BY 4.0., Retrieved [02.02.2020] from https://nowdatabase.org/now/database/, http://doi.org/10.5281/zenodo.4268068.

Smits, P. D., 2015: Expected time-invariant effects of biological traits on mammal species duration. *PNAS*, 112, 13015 – 13020.

Stanley, S. M., 1975: A theory of evolution above the species level. *Proc. Nation. Acad. Sci.* 72, 646 – 50.

HIGH DIVERSITY OF TETRAPODS IN THE LOWER PERMIAN OF THE BOSKOVICE BASIN, CZECH REPUBLIC

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The current knowledge of tetrapods from the Asselian (lowermost Permian) of the Boskovice Basin in the Czech Republic is almost exclusively based on body fossils which are limited to a few taxa of lacustrine origin. These specimens comprise extraordinarily abundant discosauriscids (Špinar, 1952; Klembara, 1995; Klembara, 2009) and some very rare temnospondyls (Augusta, 1948, Milner et al., 2007; Klembara & Steyer, 2012). No other tetrapods have been recorded from these deposits.

We report a new assemblage of tetrapod footprints, providing evidence of diverse tetrapod fauna in the Asselian ecosystem of the Boskovice Basin. The new specimens document the presence of large semiaquatic as well as fully terrestrial tetrapods and are ascribed to several ichnotaxa. These include *Amphisauropus kablikae*, *Dimetropus leisnerianus*, *Dromopus lacertoides*, *Ichniotherium cottae*, and *Limnopus vagus*, which are attributable to a wide range of trackmakers, such as large-bodied temnospondyls and seymouriamorphs, diadectomorphs, and early-diverging amniotes represented by both their major clades, sauropsids as well as synapsids. Some of the tracks further show rare and well-preserved impressions of soft tissue, such as dermal creases (see Calábková et al., 2022).

The new record of tetrapod footprints significantly expands the knowledge of tetrapod biodiversity in the lowermost Permian of the Boskovice Basin and improves our understanding of the terrestrial paleoenvironment recorded in these basinal strata.

References:

Augusta, J., 1948: Dnešní stav znalostí o stegocephalech z moravského spodního permu. *Přírodověd. sbor.,* Sbor. přírodověd. společ. v Ostravě, 9, 82–101.

Calábková, G., Březina, J. & Madzia, D., 2022: Evidence of large terrestrial seymouriamorphs in the lowermost Permian of the Czech Republic. *Papers Palaeont.,* 8, 2, 14–28.

Klembara, J., 1995: The external gills and ornamentation of the skull roof bones of the Lower Permian tetrapod *Discosauriscus austriacus* (Makowsky 1876) with remarks to its ontogeny. *Paläont. Z.,* 69, 265–281.

Klembara, J., 2009: New cranial and dental features of *Discosauriscus austriacus* (Seymouriamorpha, Discosauriscidae) and the ontogenetic conditions of *Discosauriscus*. *Spec. Pap. Palaeont.,* 81, 61–69.

Klembara, J. & Steyer, S., 2012: A new species of *Sclerocephalus* (Temnospondyli: Stereospondylomorpha) from the Early Permian of the Boskovice Basin (Czech Republic). *J. Paleont.,* 86, 302–310.

Milner, A. W., Klembara, J. & Dostál, O., 2007: A zatrachydid temnospondyl from the Lower Permian of the Boskovice Furrow in Moravia (Czech Republic). *J. Vertebr. Paleont.,* 27, 711–715.

Špinar, Z., 1952: Revize některých moravských diskosauriscidů (Labyrinthodontia). *Rozpr. Ústř. Úst. geol.,* 15, 1–115.

DISPERSED CUTICLES OF THE KLIKOV FORMATION AND THEIR DIVERSITY

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The upper Turonian to Santonian Klikov Formation is the most widespread unit of the South Bohemian basins. It is very rich in findings of plant fossils, especially reproductive organs, pollen spectra and leaf mesofossils. The Zliv locality, where the plant mesofossils come from, is located 15 km north of České Budějovice.

Well-preserved fragments of twigs and leaves, sometimes with preserved marginal parts was obtained from sediment by bulk maceration. The following is the cuticle analysis, one of the very practical ways to understand the micromorphological structures of leaves, which are often decisive in their determination. The analysis involves chemical maceration (soaking fragments in Schulze's reagent followed by potassium hydroxide) and observation of epidermal structures in light and scanning electron microscopes.

The studied material shows considerable diversity at the meso- and micro-morphological levels. There are twigs of *Geinitzia* type, fragments of angiosperm leaves bearing thin cuticles, indicating moist environment, plants with thick cuticles indicating various degree of water stress. Cuticle analysis revealed considerable stomatal heterogeneity. There are specimens with strictly one type of stomata (cyclocytic), but also specimens showing more than one type (cyclocytic, paracytic, anomocytic) in various combinations. Stomata are arranged irregularly or in rows with stomatal axes oriented mostly randomly, in some cases in one direction. Using cuticle analysis fragments of leaves can be classified unambiguously to Platanaceae and Lauraceae. Leaves of juglandoid affinity can represent foliage of plants of Normapolles complex. Their fruits (*Caryanthus*, *Budvaricarpus*, are the most frequent among carpological mesofossils. Some cuticle fragments could be identified as monocotyledonous plants without further specification.

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RESEARCH ON DENTAL PHENOTYPE OF ARVICOLID SPECIES *MICROTUS GREGALIS* FROM SELECTED MIDDLE PLEISTOCENE TO HOLOCENE LOCALITIES FROM CZECH REPUBLIC AND SLOVAKIA

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Microtus species can be found throughout Europe, North America and Asia. They evolveda typical, ever-growing complex molars, as an adaptation to a highly abrasive nutrition consisting of grasses, grains, roots and barks (Guthrie, 1971). The diversification of Microtus, the most rapidly evolving taxa of the Quaternary, is one of the most extraordinary characteristics of rodent evolution in the Plio-Pleistocene (Killick, 2012). The ongoing study examines the intraspecific morphological variability of many *Microtus gregalis* populations. An extensive dataset was obtained from a series of sites in Czechia (C718, Bišilu, Maršov,…), Moravia (Stránska skála cave, Holštejnská cave, Tučín, Zkamenělý zámek, Balcarka, Srnčí,…) and Slovakia (Včeláre 11, Bojnice, Muráň, Šarkanice, Maštaľná,…).

The study uses 2D geometric morphometrics methods and standard biometric methods to evaluate subtle differences in the first lower molar´s (m1) morphology of *Microtus gregalis* populations. In total 3 168 specimens were used for standard biometric methods. Due to fragmentation of the fossil teeth, only 1 524 specimens could be used for geometric morphometrics analyses. Principal Component Analysis (PCA) indicates that the most morphological variability is associated with the width of the posterior loop, curvature and length of the anteroconid complex relatively to the tooth´s length (PC1) and with width and length of the anteroconid complex and confluence of the fifth and sixth triangle (PC2). PCA´s results were confirmed by factor analysis on the whole obtained dataset. Discriminant function analysis rejected the null hypothesis of no difference in multivariate means for every pair of studied populations. Permutation test for Procrustes distances and for Mahalonobis distances through 1 000 permutations proved the significance of discriminant function analysis. Multivariate regression analysis was used to evaluate changes in m1 morphology through the Middle Pleistocene to Holocene period. Significant values were identified through 1 000 permutations. However, locality a time period explains only 2,6877 % of the overall variation of the m1 morphology.

References:

Guthrie, R. D. & Matthews, J. V., 1971: The Cape Deceit fauna – early Pleistocene mammalian assemblage from the Alaskan Arctic. *Quat. Res*., 1, 474–510.

Killick, L. E., 2012: Geometric Morphometric analysis of the Microtus M1 and its application to Early Middle Pleistocene in the UK. *Durham theses, Durham University,* p. 415.

JURASSIC-CRETACEOUS AND CRETACEOUS-PALEOGENE BOUNDARY EVENTS BASED ON MAGNETIC AND GEOCHEMICAL DATA

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Two boundary intervals, between the Jurassic and Cretaceous periods (J/K; Tithonian – Berriasian) and the Cretaceous and Paleogene periods (K/Pg), are being studied at the Paleomagnetic laboratory of the Institute of Geology of the Czech Academy of Sciences.

The J/K is the last boundary between stratigraphic periods not yet defined by the International Commission on Stratigraphy. The multidisciplinary research of the carbonate sequences from several J/K localities from Czech, Slovakia, Poland, Austria, France and Serbia, is currently being carried out. Within this project, several classic and new J/K sites: e.g. Kurovice (CZ), Ropice (CZ), Jahodná (CZ), Snežnica (SK), Rettenbacher (A) and Goleszow (PL), are studied with main emphasis on magnetostratigraphy (Fig. 1). At several sites, the Silesian Unit (Ropice, Goleszow, etc.) is found in river- and stream-cuts or abandoned quarries and expose slope marlstones and pebbly mudstones (Vendryně Fm) with overlying calciturbidites (Těšín Limestone Fm), where J/K transition is expected. Another site, Snežnica, exposes Tithonian-Berriasian hemipelagic lime-stones within 300 m thick succession. Active Rettenbacher quarry in Northern Calcareous Alps exposes sequence of 17 m thick thin-bedded late Tithonian to late Berriasian limestones of the Oberalm Fm Fossil record of above mentioned J/K sites often includes calpionellids, foraminifers, dinocysts, nannofossils as well as rare ammonites and belemnites, etc.

The second research project is focused on the K/Pg boundary which is associated with one of the five largest mass extinctions in the Earth's history. This research focuses on the Czech and Slovak Outer Carpathian sections (including sub-CCD facies) with the emphasis on local magnetic and paleoenvironmental variations within the global cataclysm event. The Uzgruň (CZ), Bukovec (CZ), Žilina (SK) and Kršteňany (SK) localities

(Fig. 1) were chosen for this multidisciplinary study. The Uzgruň stream-cut locality in the Magura Unit (Soláň Fm) reveals the 16 m thick continuous composite section which is combined from four turbidite subsections in individual tectonic slices. The Bukovec section (Silesian Unit), consists of isolated silty mudstone outcrops of the Upper Maastrichtian – Lower Paleocene strata. Fossil record of these stream-cut localities comprises dinoflagellate cysts, agglutinated foraminifers, pyritized radiolarians. Moreover, the K/Pg transition is studied in two drill cores, Žilina and Kršteňany. The K/Pg in Žilina (ZA-1) 75 m drill core is developed in bathyal environment within Late Cretaceous – Early Eocene plankton-rich sequence. Whereas 250 m thick Kršteňany (KRS-3) drill core comprises Late Cretaceous – Middle Eocene formations and consists of terrestrial to marine facies. Fossil records of these drilled sections include foraminifers and nannofossils, etc.

Fig. 1. Schematic map of selected J/K (white) and K/Pg (black) localities.

Rock- and paleomagnetic measurements in combination with geochemical analyzes and biostratigraphy of above mentioned J/K and K/Pg localities have either recently been carried out or are currently ongoing. Moreover, the existing magnetic and biostratigraphic data of several J/K Carpathian sections was compared and combined with first results of Gamma-ray spectrometry. The magnetic properties as well as mercury concentrations vary within studied J/K and K/Pg localities. However, in general, mostly paramagnetic signal with occasional higher magnetic susceptibilities (carried mainly by magnetite and occasional hematite) is observed. The obtained magnetic signature and geochemistry (Hg, TOC, etc.) can illustrate the paleoenvironmental changes. The magnetic and geochemical (Hg) results of these studies and their paleoenvironmental implications will be presented.

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HEALED INJURIES IN TWO ORDOVICIAN TRILOBITES

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Anomalies of the biomineralized exoskeleton of trilobites commonly record injuries resulting from predation and offer an important insight into Paleozoic ecosystems. Direct predator-prey relationships, such as traces of healed damage of trilobite exoskeletons are only rarely observed. Such healed injuries clearly indicate failed predation and document the position of trilobites as prey in Cambrian to Carboniferous ecosystems. In this contribution, we document remarkable exoskeletons of two Ordovician trilobite showing healed injuries.

The articulated and partly enrolled exoskeleton of the nektobenthic trilobite *Parabarrandia bohemica* (Novák, 1884) exhibits a prominent palaeopathological anomaly in its pygidium. We interpret this anomaly as a healed traumatic injury and attribute this damage to a failed predatory attack. The subsequently healed injury is classified as the ichnogenus *Oichnus* Bromley, 1981. The structure on this anomalous pygidium is strongly reminiscent of injuries caused by octopods and a large cephalopod is proposed as a potential durophagous predator responsible for this injury. However, a biting by an unknown arthropod in trilobite soft-shelled stage could not be excluded (Fatka et al., submited).

A substantial reduction of the eye surface associated with changes in morphology and surface structure in the cephalon of *Dalmanitina socialis* (Barrande, 1846) is analyzed and this anomalous cephalon is interpreted as the result of a healed injury after an unsuccessful predatory attack. Any activity of endoparasites resulting in such anomaly is excluded. Based on the presumed mechanism of injury, a 'large arthropod' is proposed to be the potential attacker. By analogy with eye development and regeneration in the recent Australian crayfish, the regeneration of the damaged trilobite eye, blastema and possibly other mechanisms were involved (Fatka et al., 2021).

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References:

Barrande, J., 1846: Notice préliminaire sur le Système Silurien et les trilobites de Bohême. C. L. Hirschfeld, libraire, Leipsic, 97 p.

Fatka, O., Budil, P. & Mikuláš, R., submitted: Healed injury in a nektobenthic trilobite: “Octopus-like” predatory style in Middle Ordovician? *Geol. Croat.*

Fatka, O., Budil, P. & Zicha, O., 2021: Exoskeletal and eye repair in Dalmanitina socialis (Trilobita): An example of blastemal regeneration in the Ordovician? *Int. J. Paleopathol.,* 34, 113 – 121.

Novák, O. P., 1884: Studien an Hypostomen Böhmischer Trilobiten Nr. II. *Sitz.-Ber. Kön. Böhm. Gesell. Wiss. (Prag),* 212 – 229.

THE J/K BOUNDARY PROBLEM: WHERE SHALL WE LOOK FOR A GLOBAL MARKER?

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The current Jurassic/Cretaceous (J/K) boundary is defined at the bottom of the Calpionella alpina Subzone. It is defined as “C. alpina ecoevent” and characterized by increase in the relative abundance of small spherical forms of *C. alpina*, decline of large Calpionella species (*C. grandalpina*), Disappearance of the homeomorph of C. elliptica (*C. elliptalpina*) and last occurrence of *Crassicollaria brevis* and *Cr. massutiniana.* The event is consistently correlated with middle part of magnetosubzone M19n2n, and accompanied by sequence of calcareous nannofossil events: first occurrences of *Nannoconus wintereri*, *N. steinmannii minor* and *N. kamptneri minor*. Although the C. alpina ecoevent is easily and routinely applied as the Tithonian/Berriasian boundary in the pelagic and hemipelagic sections of the Tethyan domain, it is sometimes contested by stratigraphic geologists working in other regions. In fact, the Tethyan sections developed in Ammonitico Rosso and Maiolica facies provide the best quality, continuous chronostratigraphic callibration, based on integrated calpionellid, calcareous nannofossil and magnetic stratigraphy, ranging from the base of late Tithonian up to the Berriasian/Valanginian boundary. However, the late Tithonian/early Berriasian regression in Central Europe and Russian Platform, and profound palaeobiogeographical provincialism, is the main reason that the Alpina ecoevent is often quite difficult to identify reliably outside Tethys. Therefore, the attempts are undertaken to test a correlation potential of several stratigraphic levels in a broad J/K boundary interval, ranging from the late Tithonian (top of Microcanthum ammonite Zone) to lower Berriasian (base Occitanica ammonite Zone), shifting the boundary ca. 1.5 My up or down from the present-day position. Additionally, a climatostratigraphy seems to be quite promising although not fully verified approach. The major sea-level changes are apparently combined with climatic palaeohumidity variations, indicating a possibility of glacieustatic control (regression = aridification, transgression = humidification). The scenario is recently supported by palynology, chemostratigraphic and clay minerals data, as well as new documentation of glendonites in the Tithonian and Berriasian. Integration of biotic and large-scale palaeoenvironmental trends might help to overcome the well-known faunal provincialism which hitherto prevented a consensus on global definition of the J/K boundary.

THE FOSSIL RECORD OF DEEP-SEA CHONDRICHTHYAN EGG CAPSULES

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Extant chondrichthyans are either oviparous, viviparious, or ovoviviparous. Oviparous chondrinchyans lay fertilized eggs, encased in large, collagen-rich capsules, which are either attached or unattached to the bottom. The function of the capsule wall is to protect the developing embryo until it hatches up to four years after the egg was laid. Extant oviparous chondrichthyans belong to several groups, including chimaeras (Chimaeriformes, Holocephali), skates (Rajiformes, Elasmobranchii), catsharks (Scyliorhinidae, Carchariniformes, Elasmobranchii), bullhead sharks (Heterodontiformes, Elasmobranchii) and nurse sharks (Orectolobiformes, Elasmobranchii) (Fischer et al., 2014). Only three of the former groups live and reproduce in deep waters, where their egg cases can form spectacular accumulations on positive seabed features, like deep-water coral reefs or cold seep carbonates. Unlike the former, both bullhead and nurse sharks are mostly shallow water, tropical groups and do not lay their eggs in deep-waters. In addition to extant elasmobranchs, extinct groups for which oviparity and capsule production has been suggested include various Holocephali, or xenacanthiform and hybodontiform elasmobranchs. The oldest possible chondrichthyan egg capsules (*Palaeoxyris* Brongniart, 1828) are Carboniferous (Mississipian) in age and could have been laid by hybodontid sharks, whereas other Palaeozoic (e.g. *Palaeoxyris*, *Crookalia* Chabakov, 1949; Pennsylvanian, Carboniferous), Triassic or Jurassic egg capsules were likely laid by unidentified Holocephali, hybodontiform or xenacantiform elasmobranchs.

A characteristic feature of pre-Cretaceous egg capsule records is that they all come from shallow marine, brackish or freshwater deposits.

The oldest egg capsules known from deep-sea settings are Cretaceous in age and come from both Early and Late Cretaceous seep deposits from California, Arctic Canada, and Japan. They are most similar to Eocene (e.g. *Scyliorhinotheca* Kiel, Peckmann and Simon, 2013) and Recent scyliorhynid egg capsules, for example those laid by the species of the deep-sea catshark *Apristurus* Garman, 1913, although skate affinity is also possible for some Late Cretaceous-aged specimens. Cenozoic egg capsules of Eocene and Miocene deep-sea seep deposits are also known, and these were also likely laid by deep-sea catsharks. We suggest that the observed onset of deep-sea chondrichthyan egg capsule reproduction during the Cretaceous is an actual phenomenon as indicated by the similar age of the modern deep-sea fauna (e.g. Kiel & Little, 2006; Thuy et al., 2014) and that egg capsule production among the chondrichthyans followed a general onshoree-offshore pattern as did the general evolution of marine fauna (Jablonski et al., 1983). Once established in the deep sea during the later part of the Mesozoic, oviparous elasmobranch reproduction survived there in very similar form until the present day, in spite of the end-Cretaceous mass extinction, Oceanic Anoxic Events during the Cretaceous and the Eocene, and other oceanographic perturbations.

References:

Fischer, J., Licht, M., Kriwet, J., Schneider, J. W., Buchwitz, M. & Bartsch, P., 2014: Egg capsule morphology provides new information about the interrelationship of chondrichtyan. *J. System. Palaeont.,* 12, 389–399.

Jablonski, D., Sepkoski, Jr. J. J., Bottjer, D. J. & Sheehan, D. J., 1983: Onshore-offshore patterns in the evolution of Phanerozoic shelf communities. *Science,* 222, 1123–1125.

Kiel, S. & Little, C. T. S., 2006: Cold-seep molluscs are older than the general marinemollusc fauna. *Science,* 313, 1429–1431.

Thuy, B., Gale, A. S., Kroh, A., Kucera, M., Numberger-Thuy, L. D., Reich, M. & Stöhr, S., 2012: Ancient origins of modern deep-sea fauna. *PLoS ONE* 7(10): e46913.

FORAMINIFERA FROM LOW OXYGENE ZONES IN THE CENTRAL PARATETHYS DURING THE MIDDLE MIOCENE

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Key words: Central Paratethys, Benthic Foraminifera, Paleoecology, Biostratigraphy

The traditional ecostratigraphical concept of the Central Paratethys deposits is based, amongst others, on several benthic foraminiferal ecohorizons (Grill, 1941; Papp et al., 1978; Cicha et al., 1975; Luczkowska, 1990). Nevertheless, long lasting research from this realm shows that these assemblages can be both un-isochronous and iso-chronnous. One of the most stratigraphically used horizon is low oxy event which can be well recognizable throughout the territory of Central Paratethys in the Badenian sediments. Mentioned foraminiferal assemblage is composed of benthic foraminifera tolerate to low oxy conditions, dominate with *Bulimina*, *Bolivina* and *Uvigerina* genera. Numerous eurytolerant species of calcareous and agglutinated benthic foraminifera, survive under modern dysoxia and suboxia (2–0 ml/l O_2), as well as under higher oxygen levels. Under the usual combination of oxygen depletion and organic-matter enrichment of the substrate, the populations of some of these species expand significantly. In the last decades the new studies have revealed new types of associations which can document possibly low oxy paleoenvironment, which were not used for biostratigraphy. One of such associations dominated with *Ammonia* genus formerly used as indicator of hyposaline water can prove low oxy conditions. For purpose of this study, the various indices (BFOI, A/E, domination) of revealing low oxy associations were studied. Benthic taxa were ranked into morphogroups and spatiotemporal range of each horizon was compiled. Occurrences of the low oxy tolerant foraminifera blooms were discussed in respect of known paleoenvironmental data from related site. To test stratigraphical significance of low oxy horizon we revised quantitatively evaluated data from the Western Carpathians based on our own material, available unpublished (Geofond, Nafta, a. s.) and published data. The horizons with low oxy tolerant benthic foraminifera are laterally and horizontally alternated with horizons dominated by other ecologically specialized taxa, or even by opportunistic taxa. However, also spatially restricted blooming of certain morphotypes of some low oxy foraminifera well corresponds with definition of ecostratigraphical units. The most pronounced horizon is horizon with prevailing *Bulimina* and *Bolivina* species, so called Bulimina-Bolivina Zone, widely used stratigraphically in Upper Badenian sediments, but also mentioned informally in Karpatian (Špička et Zapletalová, 1964) and Sarmatian (Filipescu a Silye, 2008) sediments. These horizons represent endemic conditions under ecological stress due to isolation of Paratethys and reappeared in the Central Paratethys several times what restricted their biostratigraphical value. They represent intervals with different type and amount of nutrients in suspension both terrigenous as well as intrabasinal origin and following oxygen consumption.

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The study was supported by the projects VEGA2/0169/19, APVV 17-0555 and APVV-20-0079.

References:

Cicha, I., Čtyroká, J., Zapletalová, I. & Canova, M., 1975: East Alps and West Carpathian Basins: Marine Zones of Benthic Foraminifera. In: Cicha, I. (ed.): Biozonal subdivision of the Upper Tertiary basins of the Eastern Alps and West Carpathians. Proceedings of the VI-th Congress RCMNS. *Prague, Geol. Surv.*, 34–40.

Filipescu, S. & Silye, L., 2008: New Paratethyan biozones of planktonic foraminifera described from the Middle Miocene of the Transylvanian Basin (Romania). *Geol. Carpath.,* 59, 537–544.

Grill, R., 1941: Stratigaphische Untersuchungen mit Hilfe von Mikrofaunen im Wiener Becken und den benachbarten Molasse-Anteilen. Ö*l u. Kohle,* 37, 595–602.

Luczkowska, E., 1990: Stratigraphically Important Agglutinated Foraminifera in the Badenian (Miocene M4) of Poland, In: Hemleben (ed.): Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera, Vol. 327 of the series NATO ASI Series, 843–857.

Špička, V. & Zapletalová, I., 1964: Nástin korelace karpatu v československé části Vídeňské pánve. *Sbor. geol. Věd., Geol. (Praha),* 5, 127–156.

Papp, A., Cicha, I., Seneš, J. & Steininger, F., 1978: Chronostratigraphie und Neostratotypen: Miozän der Zentralen Paratethys. Bd. VI: M 4 , Badenien (Moravien, Wielicien, Kosovien). *Bratislava, VEDA, Vyd. Slov. Akad. Vied,* 1–594.

EARLY OXFORDIAN OCCURRENCE OF LATE JURASSIC NEOSELACHIAN SHARK *NOTIDANOIDES MUENSTERI* (AGASSIZ, 1843) [ELASMOBRANCHII, HEXANCHIFORMES] IN BRNO-HÁDY, CZECH REPUBLIC

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In the fossil record, hexanchiform sharks are usually well discernible from other neoselachian sharks by their multi-cusped saw-like teeth. Genus *Notidanoides* MAISEY, 1986 is a group of Jurassic hexanchiform sharks, characterized by crowns consisting of one massive main cusp with smooth mesial cutting edge and up to five distal cusplets which decrease in height. According to most recent taxonomical study (Kriwet & Klug, 2014), there is currently only one valid Late Jurassic representative of this genus: *Notidanoides muensteri* (AGASSIZ, 1843); all the other Late Jurassic species are regarded as synonymous with this species (Kriwet & Klug, 2014). Its fossil record restricted to European localities suggests that *N. muensteri* (Fig. 1A) inhabited outer shelves and upper continental slopes on the northern margin of Tethys Ocean. The oldest record, represented by two isolated teeth, comes from Middle Oxfordian (Transversarium ammonite Zone) of Baden-Württemberg in Germany (Kriwet & Klug, 2014).

In Czechia, the first multi-cusped tooth assigned to *Notidanoides muensteri* was found in Kimmeridgian “ammonite limestone” of Šternberk quarry in North Bohemia (Bruder, 1882). Unfortunately, current location of this specimen is unknown. In the last decade, new material was collected at Brno-Hády in South Moravia. Studied material consists of five isolated and incomplete teeth (Fig. 1B), but their multi-cusped nature, overall morphology and diagnostic smooth mesial cutting edge of the main cusp are well preserved and allow designation to *N. muensteri*. Specimens were collected *ex situ*, but their original stratigraphic position and corresponding age can be reliably reconstructed on basis of lithological correlation of specific host facies with adjacent section (Bubík & Baldík, 2011) dated by ammonite biostratigraphy and by lithostratigraphic correlation with nearby sections at Olomučany, dated by ammonite biostratigraphy as well (Lower Oxfordian Cordatum ammonite Zone; Hykš, 2020). The nannoplankton content in samples preserving multi-cusped teeth also shows Lower Oxfordian affinity (NJ14 nannoplankton Zone). Studied collection of teeth is very valuable. Remains of *N. muensteri* were only rarely reported from nearshore, shallow-marine deposits. Collected specimens also represent the earliest known occurrence of this taxon worldwide.

References:

Agassiz, J. L. R. 1834–1844: Recherches sur les Poissons fossiles. *Imprimerie de Petitpierre, Neuchatel*, 1–5, 1–1420.

Bruder, G., 1882: Neue Beiträge zur Kenntniss der Juraablagerungen im nördlichen Böhmen. *Z. Naturwiss.*, 85, 450–489.

Bubík, M. & Baldík, V., 2011: Preliminary results of stratigraphic investigations of the Jura at Hády Hill near Brno. *Geol. výzk. Mor Slez. (Brno)*, 18, 2, 74–78.

Hykš, P., 2020: Revision of Jurassic ammonite fauna from the Moravian Karst and Brno. MS, master's thesis. Brno, Fac. Sci., Masaryk University, 1–70. [in Czech] https://is.muni.cz/th/ugqmj/.

Kriwet, J. & Klug, S., 2014: Dental Patterns of the Stem-Group Hexanchoid Shark, *Notidanoides muensteri* (Elasmobranchii, Hexanchiformes). *J. Vertebr. Paleont.*, 34, 6, 1292–1306.

Maisey, J. G., 1986: The Upper Jurassic Hexanchoid elasmobranch Notidanoides n. g. *Neu. Jb. Geol. Paläont., Abh.*, 172, 83–106.

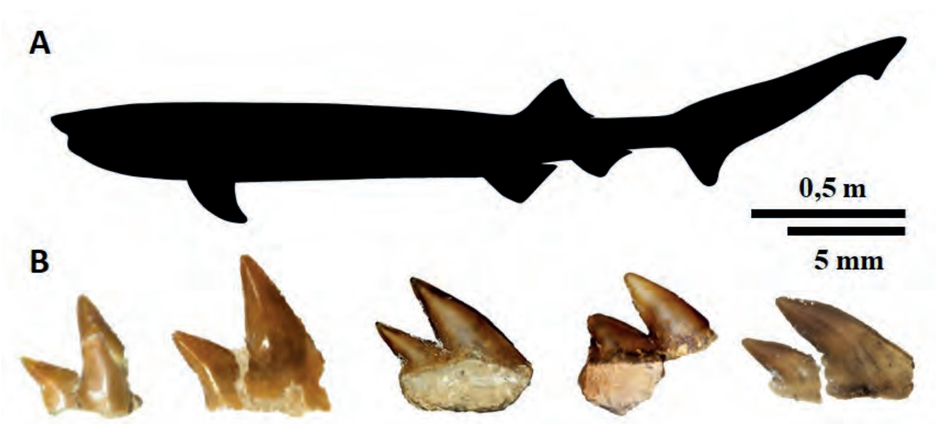

Fig. 1A: Reconstruction of *Notidanoides muensteri* (Agassiz, 1843) by Dean Schnabel. B: Teeth of *Notidanoides muensteri* (Agassiz, 1843) collected at Brno-Hády by Ján Fajčák, Lubomír Svoboda and Petr Hykš.

DECAPOD CRUSTACEANS OF THE BADENIAN – STATE OF ART

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During the Oligocene and Miocene, the northern domain of the circum-Mediterranean area, covering a large part of the European continent, was called Paratethys and was further differentiated into the Western, Central and Eastern part. The most widespread strata from the Central Paratethys are of the Badenian age (ca. 15.2–12.6 million years ago; Kováč et al., 2017). During that time, shallow marine environments hosted a diversity of organisms, including decapod crustaceans. Until now, more than a hundred decapod species have been identified from the Badenian strata of Neogene basins of the Central Paratethys (Hyžný, 2016).

Decapods are highly organized malacostracan arthropods with the mineralized exoskeleton and body consisting of a cephalothorax, a segmented pleon, and appendages attached to body segments. Decapods normally have five pairs of walking legs; in various decapod groups, cheliped (claws) are present on at least the first pair, although claws are not developed at all in achelatan lobsters. To date, remains of six major decapod clades have been identified in the Badenian strata of the Central Paratethys, including representatives of Caridea, Gebiidea, Axiidea, Achelata, Anomura, and Brachyura. Carideans are represented by remains of alpheid pistol shrimps. Remains of gebiideans are limited to isolated cephalic carapace shields and cheliped elements of mud shrimps. Axiideans are represented by a number of ghost shrimps, invariably preserved as cheliped elements. A single occurrence of Achelata is known. From anomurans, hermit crabs (Paguroidea), squat lobsters (Galatheidae), porcellain crabs (Porcellanidae), and sand crabs (Albuneidae) were identified based on isolated cheliped elements and/or dorsal carapace remains. True crabs (Brachyura) are among the most common and most diverse decapod remains. Fossil remains of Badenian decapods, although incomplete and/or fragmentary usually exhibit enough characters for taxonomic evaluation if compared thoroughly with extant material.

Neogene Paratethyan basins with Badenian decapods include the Vienna, Styrian, Hrvatsko-Zagorje, Slovenian, Mura, Tuzla, Danube, Pannonian, Novohrad-Nógrad, and Carpathian Foreland basins. From these, the Vienna and Pannonian basins yielded the largest number of Badenian decapod species, owing to the preferential collection efforts of scholars and the presence of reefal settings. From 176 species-level decapod taxa identified in the Oligocene and Miocene of the Western and Central Paratethys, only 60 do not occur in the Badenian strata (Hyžný, 2016). More than 60 decapod species were recorded both from the Pannonian Basin (86 species) and the Vienna Basin (65 species), whereas other Neogene basins yielded less than 50 decapod species. Two cities, Budapest and Vienna, with a long tradition in the fossil decapod research, are located in the respective basins, pressumably owing to the oversampling in comparison with other areas. Moreover, the presence of numerous outcrops with the Badenian strata in the vicinity of Budapest and Vienna contributed to preferential focus of the scholars on these strata. Thus, high decapod species diversity in the upper Badenian of the Pannonian Basin is partially influenced by scientific contributions of Imre Lőrenthey (Lőrenthey & Beurlen, 1929) and Pál Müller (Müller, 1984), whereas high diversity of decapod crustaceans in the Vienna Basin owes much to the efforts of Friedrich Bachmayer (e.g., Bachmayer, 1953).

Decapods are among the most abundant reef-associated with a well-documented fossil record. Decapod diversity is not only elevated in reefs; reefs were also postulated to be one of the drivers of decapod evolution. Central Paratethyan reefal settings included coral patch reefs, coral carpets, and algal-vermetid reefs (Pisera, 1996). Diverse coral-associated decapod associations are known from the lower Badenian strata of the Styrian, Vienna, and Pannonian basins and the upper Badenian strata of the Pannonian Basin. Decapods associated with coralgal-vermetid reefs were reported from the upper Badenian strata of the Carpathian Foreland Basin. Badenian decapods of the Central Paratethys exhibited relatively homogeneous distribution. However, the late Badenian decapod assemblages differed taxonomically from the early Badenian ones (Müller, 1984; Hyžný, 2016). The time factor, including speciation, immigration from other provinces and/or extinction, can explain temporal differences among assemblages within the same environment.

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References:

Bachmayer, F., 1953: Die Dekapodenfauna des tortonischen Leithakalkes von Deutsch-Altenburg (Niederösterreich). *Mitt. Geol. Gesell. (Wien),* 44 (for 1951), 237–262.

Hyžný, M., 2016: Diversity and distribution of the Oligocene and Miocene decapod crustaceans (Crustacea: Malacostraca) of the Western and Central Paratethys. *Geol. Carpath.,* 67, 471–494.

Kováč, M., Hudáčková, N., Halásová, E., Kováčová, M., Holcová, K., Oszczypko-Clowes, M., Báldi, K., Less, G., Nagymarosy, A., Ruman, A. & Klučiar, T., 2017: The Central Paratethys palaeoceanography: a water circulation model based on microfossil proxies, climate, and changes of depositional environment. *Acta Geol. Slov.,* 9, 75–114.

Lőrenthey, E. & Beurlen, K., 1929: Die fossilen Dekapoden der Länder der Ungarischen Krone. *Geol. Hun., Ser.Palaeont.,* 3, 1–421.

Müller, P., 1984: Decapod Crustacea of the Badenian. *Geol. Hung., Ser. Palaeont.,* 42, 3–317.

Pisera, A., 1996: Miocene reefs of the Paratethys: a review. *SEPM Conc. Sediment. Paleont*., 5, 97–104.

MIXOXYLON AUSTRALE GEN. ET SP. NOV., A UNIQUE HOMOXYLOUS WOOD WITH NON-ANGIOSPERM AFFINITY, AND ITS ADAPTATION STRATEGY TO SPECIFIC POLAR INSOLATION CYCLE CONDITIONS, BASED ON FOSSIL WOOD ANATOMY AND GROWTH RING STRUCTURE: LOWER CRETACEOUS OF ANTARCTICA (ALBIAN, JAMES ROSS ISLAND)

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The extensive palaeobotanical record from the Antarctic region proves that during a greenhouse type of climate, this region was densely inhabited by vegetation (Cantrill & Poole, 2012; Sakala & Vodražka, 2014). The new homoxylous wood comes from the Albian Lewis Hill Member of the Whisky Bay Formation of James Ross Island. A unique combination of features allows identification of a new fossil wood genus: *Mixoxylon australe* Chernomorets & Sakala, gen. et sp. nov. (Chernomorets & Sakala, 2021). *Mixoxylon* wood may be related to *Sahnioxylon* Bose & Sah from the Antarctic region, but with differences in indistinct growth rings, earlywood zone significantly wider than latewood, rays exclusively uniseriate with distinctly pitted tangential and horizontal walls. Therefore, this new wood is assigned to a new conifer-like fossil wood genus (Chernomorets & Sakala, 2021).

Mixoxylon lived in the specific palaeoenvironmental conditions of high-latitude regions, with half-year long mild polar nights. Cretaceous vegetation had been responding to these specific conditions using two different adaptation strategies: being evergreen or deciduous (Falcon-Lang, 2000). Growth rings of *Mixoxylon* are ‘normal’, with the earlywood zone more developed than the latewood zone, and a gradual transition between them. Those features are rather typical for evergreen conifers, while similar woods most likely had a completely different adaptation strategy (indicated by latewood zone more developed than earlywood zone) (Lemoigne & Torres, 1988).

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References:

Cantrill, D. J. & Poole, I., 2012: The vegetation of Antarctica through geological time. *Cambridge*, *Cambridge University Press*, 480 pp.

Chermomorets, O. & Sakala, J., 2021: *Mixoxylon australe* gen. et sp. nov., a unique homoxylous wood with non-angiosperm affinity from the Lower Cretaceous of Antarctica (Albian, James Ross Island). *Antarctic Sci.* (in press).

Falcon-Lang, H. J., 2000: The relationship between leaf longevity and growth ring markedness in modern conifer woods and its implications for palaeoclimatic studies. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 160, 317–328.

Lemoigne, Y. & Torres, T., 1988: Paléoxylogie de l'Antarctide: *Sahnioxylon antarcticum* n. sp. et interprétation de la double zonation des cernes des bois secondaires du genre de structure (parataxon) *Sahnioxylon* Bose et Sah, 1954. *Compt. rendus Acad. Sci., Sér., 2, Mécanique, physique, chimie, Sci. univ., Sci. terre,* 306, 939–945.

Sakala, J. & Vodrážka, R., 2014: A new species of *Antarctoxylon*: a contribution to the early angiosperm ecosystem of Antarctica during the late Cretaceous. *Antarctic Sci.,* 26, 371–376.

PALYNOLOGY AND PALAEOECOLOGY OF THE LATE OLIGOCENE FROM SOUTHWESTERN BULGARIA

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The fossil flora of Bulgaria provides important information concerning floristic transformation and climatic change in Southeastern Europe. The floristic evolution in the Palaeogene is of particular importance for understanding its genesis and regional characteristics. During the Oligocene, a gradual change from a palaeotropical to an arctotertiary type of vegetation took place (Mai, 1995). This change was probably climatically forced and is well documented in the Oligocene sediments of Bulgaria. In this report, we analyze and compare two late Oligocene floras from southwestern Bulgaria from a palaeoecological and palaeoeclimatic viewpoint.

Vegetation change during this time frame was triggered by both global climatic evolution and regional patterns created by changing palaeogeography. Signals from both processes obviously overlap, making it impossible in some cases to separate their tracks. The material we studied comes from outcrops in the Bobovdol and Pernik Basins. Both are located in SW Bulgaria and represent an elongated intramontane graben system that was transformed into freshwater basins where thick lake-marsh sediments of mollasse type were deposited (Vatsev et al., 2013). The coal-bearing Palaeogene sediments were deposited over denuded Triassic and Jurassic sediments and crystalline schists. Due to the economic importance of coal, the geology of the basins is comparatively well studied.

In the present report, the palynological samples from Bobovdol and Pernik Basin were analyzed and compared for the first time. Vegetation and palaeoclimate analyse were performed. The data indicate a wide distribution of mixed mesophytic forest palaeocoenoses showing warm and humid subtropical to warm temperate climate, and mild and moderately humid environments. Climate change and vegetation dynamics were traced out. To obtain quantitative climate data, Coexistence Approach (Mosbrugger and Utescher, 1997; Utescher et al., 2014) was applied. Analysis of the paleoclimate shows a possible cooling trend in the latest Oligocene, probably forced by a global climate cooling at that time. In all microfloras analyzed, the majority of taxa indicate that there was no true dry season and that the climate was overall warm and humid.

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References:

Mai, D. H., 1995: Tertiäre Vegetationsgeschichte Europas. *G. Fischer, Jena*.

Mosbrugger, V. & Utescher, T., 1997: The Coexistence Approach – a method for quantitative reconstructions of Tertiary terrestrial palaeoclimate data using plant fossils. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 134, 1 – 4, 61 – 86.

Utescher, T., Bruch, A. A., Erdei, B., François, L., Ivanov, D., Jacques, F. M. B., Kern, A. K., & Liu, Y.-S.(C.), Mosbrugger, V. & Spicer, R.A., 2014: The coexistence approach – Theoretical background and practical considerations of using plant fossils for climate quantification. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 410, 58 – 73.

Vatsev, M. Kamenov, B. & Dzhuranov, S., 2003: Depositional stages and correlation of the Paleogene from the graben basins in southwest Bulgaria. In: *50 years University of Mining and Geology “St. Ivan Rilski” Annual, 46, Geol. Geophys.,* Sofia, 207 – 211.

BERRIASIAN-HAUTERIVIAN MICROFOSSIL ASSOCIATIONS ACROSS THE DEMISE AND DROWNING OF THE SLIVNITSA CARBONATE PLATFORM, SOUTHWEST BULGARIA

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The present study focuses on the biostratigraphy and sedimentology of the upper part of the southern Upper Jurassic-Lower Cretaceous carbonate platform succession and the lower part of the deeper marine Lower Cretaceous succession. The taxonomic identification of microfossil associations and the analysis of benthic foraminifera, calcareous dinoflagelatte cysts and calpionellids within the Berriasian–Hauterivian interval is based on thin sections studies.

The Upper Jurassic and Lower Cretaceous are of wide occurrence in western Bulgaria. The sediments were deposited in a bathymetrically differentiated basin, associated with the gradual emergence of the southern landmass and formation of the Central Moesian Basin. The shallow marine sections are located in the southwestern prolongation of the Western Moesian Carbonate Platform and part of them belong to the Slivnitsa carbonate platform (West Srednogorie Unit, Bulgaria).

Three stratigraphic sections of lowermost Cretaceous rocks were studied in the field. They are located east of Kalotina village (Zabarde region), north of Dragoman town (Chepan Mountain) and on Chavchi kamak summit (Tri ushi heights), respectively. The uppermost 25–30 m of Slivnitsa Formation and the lower to middle parts (20–50 m) of Salash Formation were described macroscopically in terms of rock colors, stratification pattern, lithology, sedimentary structures and textures. The Slivnitsa Fm consists of thick-bedded, light grey, mostly bioclastic and intraclastic limestones that contain a large number of benthic foraminifera as well as algae, corals, rudists, brachiopods, crinoids, gastropods and other benthic forms. These rocks were deposited in a shallow subtidal, mainly high-energy environment and are characterized by high abundance of agglutinated benthic foraminifers. The overlying Salash Fm consists of thin- to medium-bedded, dark grey-brownish limestones and marls with calcareous benthic foraminifera and planktic microfossils such as calcareous dinoflagellate cysts and calpionellids. The rocks referred to as Salash Fm were deposited in a low-energy, deeper subtidal environment.

The most important species of benthic foraminifera from stratigraphic point of view were found in the Slivnitsa Formation. They include mainly agglutinated taxa: *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti), *Montsalevia elevata* Zaninetti, Salvini-Bonnard, Charollais & Decrouez, *Haplophragmoides joukowskyi* (Charollais, Brönnimann & Zaninetti), *Valdanchella miliani* (Schroeder), *Mayncina bulgarica* Laug, Peybernes & Rey, *Paracoskinolina pfenderae* Canerot & Moullade, *Moulladella jourdanensis* (Foury & Moullade), *Campanellula* cf. *capuensis* De Castro, *Novalesia* sp., *Vercorsella* sp. and others. The number of large benthic foraminifers in the Salash Formation sharply decreases. Small foraminifera with calcareous wall *Meandrospira favrei* (Charollais, Brönnimann & Zaninetti), *Patellina turriculata* Dieni & Massari, *Istriloculina eliptica* (Iovcheva), *Istriloculina emiliae* Neagu), *Ichnusella infragranulata* (Noth) together with planktic organisms (calcareous dinocysts and calpionellids) appear.

The determination of the age of the two lithostratigraphic units was made on the basis of microfossil associations and the hypothesis of diachronous drowning of the Slivnitsa carbonate platform was confirmed.

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A SEDIMENTARY AND GEOCHEMICAL RECORD OF THE TOARCIAN OCEANIC ANOXIC EVENT (TOAE) IN THE KRÍŽNA UNIT OF THE EASTERN TATRA MOUNTAINS

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The study has been conducted in the Polish Eastern Tatra Mts., which belong to the Central Western Carpathians. The investigated 120 m thick succession, which is exposed in the Sucha Woda valley, is dated based on ammonites to the interval comprising the Pliensbachian and the Toarcian. The lower part of this section, which is Pliensbachian in age, is composed of spiculites and spiculite limestones possessing wackestone to packstone microfacies. The upper part of the section (being Toarcian in age), consists of about 88 meter thick marly and marly limestone deposits with radiolarians (wackestones to packstones in microfacies). The Lower Toarcian fragment of this the latter part of the section, where anomalous, very low $\delta^{13}C_{carbonate}$ values occur, is of particular interest to geochemists. The carbonate $\delta^{13}C$ values show there a short-term negative excursion from ca. 1.4 to ca. –6.4 ‰VPDB. It should be correlate with the Toarcian Oceanic Anoxic Event (TOAE; also called the Jenkyns Event) dated to the upper part of Falciferum Subzone of the Serpentinum Zone of the Lower Toarcian.

In order to determine the depositional changes related to this event, MS measurements and a gamma ray spectrometer analysis were conducted. A general increase in the K and Th contents along with higher MS values follow the TOAE, which points the prolonged period of the enhanced delivery of terrigenous material and nutrients to the basin. These phenomena are linked to increased weathering rates of land areas under hot and humid climate. High nutrients input to the oceans was likely responsible for an increase in water bioproductivity, which along with water stratification translated into limited oxygenation of the bottom sediments.

PALINOSTRATIGRAPHY OF THE NAMURIAN BIAŁY KAMIEŃ FORMATION IN N PART OF THE INTRA-SUDETIC BASIN (SUDETES, SW POLAND)

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Rocks of the Biały Kamień Formation from the outcrops along closed railroad line near Wałbrzych (N part of the Intra-Sudetic Basin), being an unformal stratotype of this unite, were palynologically studied. This formation is approximately 400 meter thick and consists mainly of conglomerates with thin intercalations of mudstones, sandstones and siltstones, representing the terrestrial facies.

The macrofloral stratigraphic studies dated these rocks on the Upper Namurian – Lower Westphalian (Gothan & Gropp, 1933) and indicated on the stratigraphic gap between Wałbrzych and Biały Kamień Formations as well as “floristic leap” recorded in these rocks. The previous palynologic studies assigned discussed rocks to upper Namurian B – Westphalian A (Górecka, 1968, 1969). However, these studies were carried out before the criteria of modern Carboniferous miospore zonation were established, but their conclusions denied the existence of a stratigraphic gap and did not confirm the influence of “floristic leap” on the composition of miospore assemblages.

During recent palynostratigraphical studies rich and taxonomically diversified miospore assemblage, consisting of 195 miospore taxa, was determined. Two miospore zones were recognized. The zone KV has been documented in rocks of the lower part of the formation due to presence of *Crassispora kosankei* and *Grumosisporites varioreticulatus*. In its higher part appearence of *Raistrickia fulva*, *Dictyotriletes muricatus* and *Dictyotriletes bireticulatu*s indicate, that these rocks belong to the zone FR (Owens et al., 2004). As the upper part of the underlying Wałbrzych Formation belongs to the SR miospore subzone, the obtained results confirm the lack of a stratigraphic gap between these formations. The gradual changes in the composition of the miospore assemblage also contradict any sudden change of the parent plant communities composition. The miospore studies were filled by palynofacial analysis, which revealed abundance of terrestrial plant fragments and miospores, which is typical to sediments of the alluvial plain.

References:

Gothan, W. & Gropp, W., 1933: Palaobotanical-stratigraphic investigations in Lower Silesia. Carboniferous. *Berg. Hutt.-Salinen.,* 81, 88–98.

Górecka, T., 1968: The problem of the Namurian-Westphalian border in the north-western part of the Intra-Sudetic Basin. *Geol. Quart.,* 12, 1, 51–59.

Górecka, T., 1969: The stratigraphy of the Biały Kamień layers in the north-western part of the Intra-Sudetic Basin based on palynological studies. *Bull. Geol. Inst.,* 230, 167–292.

Owens, B., 2004: Taxonomy Online 2: The 'Bernard Owens Collection' of single grain mount palynological slides: Carboniferous spores part I.

FOSSIL ASSOCIATIONS FROM TURONIAN, UPPER CRETACEOUS HYDROTHERMAL VENT DEPOSITS FROM CYPRUS, A GLIMPSE INTO MESOZOIC HYDROTHERMAL VENT ECOSYSTEMS

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Modern hydrothermal vent communities are unusual associations of animals living in extreme environments around sulphide chimneys on the deep-sea floor. Feeding strategies and entire structure of such communities are based on chemosynthesis by microbial primary producers. Molecular phylogenetic divergence estimates indicate that many of the dominant vent taxa arose during the Cenozoic and Cretaceous; however, the fossil record of vent communities from these time periods is exceptionally poor. One occurrence of such Cretaceous vent communities pertains to six volcanogenic massive sulphide deposits in the Troodos ophiolite of Cyprus. These deposits represent hydrothermal activity on deep (2 500–5 000 m) arc-related spreading ridge over several million years during the Late Cretaceous. The Cyprus vent communities consist of worm tubes, representing possible vestimentiferans and serpulids, together with numerous abyssochrysoid gastropods. All gastropods belong new species and one new genus is also identified. The gastropod fauna contains the first representatives of the genera *Desbruyeresia*, *Hokkaidoconcha*, *Ascheria* and *Paskentana* from hydrothermal vents, and also the youngest representative of the latter genus in any environment. A single gaudryceratid ammonite from one of the vent sites most likely represents a water-logged shell that made its way down from surface waters. This fauna is just one of two hydrothermal vent communities known containing other fossils than worm tubes in the Mesozoic times.

THE VACUUM CAST EMBEDDING AND X-RAY MICRO-COMPUTED TOMOGRAPHY AS STANDARD METHODS TO VISUALISE BIOEROSION TRACES IN SERPULID TUBES

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Bioerosion in tubes of serpulid polychaetes from the late Cenomanian and early Turonian of the Bohemian Cretaceous Basin in the Czech Republic and the late Cenomanian of Le Mans region in France were studied by combination of non-invasive and invasive methods: micro-computed tomography and vacuum cast-embedding technique producing polymer resin casts (Fig. 1). Both micro-CT and epoxy vacuum embedding followed by SEM observations is widely regarded as the standard tools for reasonable 3D visualization and spatial distribution of inner structures inside various substrates (Tapanila, 2008; Wishak, 2012). Serpulid polychaetes represent specific substrate determined by curvature and small thickness of the tube wall measuring 0.5–0.8 mm in diameter only. The maximum borehole diameter of macrobioerosional traces investigated in this study varies between 0.01–0.4 mm (mean = 0.12 mm) (Kočová Veselská et al., 2021).

For visualising these tiny structures, X-ray micro-tomograph SkyScan 1172 was chosen first for its non-destructive nature. The great benefit of micro-CT is its ability to display empty borings (air space) or borings filled with dense matrix. Compared to SEM, micro-CT has the advantage of allowing the object to be viewed in 3D through the full 360° range (Tapanila, 2008). The results, however, depend critically on the contrast in density and atomic number between the fossil material and the respective boring infilling. To enhanced better contrast between calcitic/aragonitic serpulid tubes and their infilling, Al 0.5 mm, Al + Cu and Cu 1 mm pre-filters were used. Moreover, resolutions of less than 5 µm cannot be effectively achieved (Heřmanová et al., 2020).

Vacuum cast-embedding is the process of filling tunnels with epoxy resin under vacuum conditions, and dissolving the substrate via treatment with diluted hydrochloric acid (Wisshak, 2012). Although it is a destructive method, the SEM images of the resulting casts have significantly better resolution than micro-CT and thus enable to display and quantify the most delicate morphological features such as microborings as well as details of macroborings (Heřmanová et al., 2020; Wisshak, 2012). The quality of epoxy casts highly depends on adequate porosity and permeability of the boring fill. Distal parts of borings can be obscured by the epoxy casting method because of incomplete infiltration of the epoxy into the deepest, thinnest parts. This method is also unsuitable for poorly soluble (e.g. silicified) substrates and due to its destructive nature for unique or rare specimens (Tapanila, 2008; Wisshak, 2012).

Our study shows how different imaging techniques bias the description and diagnostic of bioerosion inside tiny serpulid tubes. Micro-CT in combination with vacuum cast embedding, each with its own advantages and limitations, allows for a more complete account of bioerosion, from its millimeter- to micron-scale distribution in the substrate.

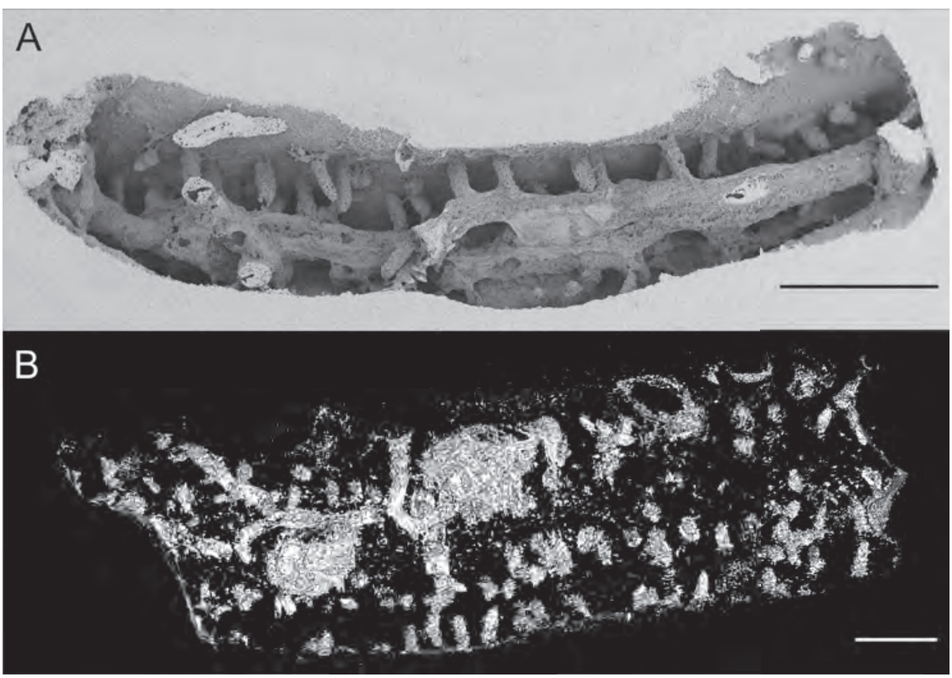

Fig. 1. A. SEM image of casted macro and microborings in the tube of *Placostegus zbyslavus* Ziegler from the Turonian of the Bohemian Cretaceous Basin. B. Micro-CT scan of *Pyrgopolon* (*P.*) *deforme* Lamarck from the late Cenomanian of Le Mans region – 3D reconstruction of the tube interior. Scale bars = 1 mm.

References:

Heřmanová, Z., Bruthansová, J., Holcová, K., Mikuláš, R., Kočová Veselská, M., Kočí, T., Dudák, J. & Vohník, M., 2020: Benefits and limits of x-ray micro-computed tomography for visualization of colonization and bioerosion of shelled organisms. *PPalaeont. Electron.,* 23, 2, a23.

Kočová Veselská, M., Kočí, T., Jäger, M., Mikuláš, R., Heřmanová, Z., Morel, N. & Šamánek, J., 2021: Sclerobionts on tubes of the serpulid *Pyrgopolon* (*Pyrgopolon*) *deforme* (Lamarck, 1818) from the Upper Cenomanian in Le Mans region, France. *Cret. Res.,* 125, 104 – 873.

Tapanila, L., 2008: The medium is the message: imaging a complex microboring (*Pyrodendrina cupra* igen. n., isp. n.) from the early Paleozoic of Anticosti Island, Canada. In: Wisshak, M. & Tapanila, L. (eds.): *Current Developments in Bioerosion*. Berlin, Springer, 123 – 145.

Wisshak, M., 2012: Microbioerosion. In: Knaust: D. & Bromley, R.G. (eds.), Trace Fossils as Indicators of Sedimentary Environments. *Develop. Sediment.,* 64, 213 – 243. Elsevier, Amsterdam.

CHEMICAL EXTRACTION OF MACRO – TO MESOSCOPIC FOSSIL REMAINS FROM THE LOWER PALEOZOIC OF THE BARRANDIAN AREA

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Various remains of macroscopic organisms are a compound of palynological residues (e.g. Gensel et al., 1990) which include cuticular fragments of both metazoan and plant origin, parts of graptolites and other fossil remains. Often these fossil elements are difficult to classify and to assign to the parent organism. Consequently, in this study, we are attempting a complementary approach combining micro- and macrofossil records.

For the extraction of micro- and mesoscopic fossils, we utilize both standard palynological methods and the “low-manipulation HF extraction” method (Butterfield & Harvey, 2012). Furthermore, we utilize chemical extraction methods for the extraction of individual elements from remains of macrofossil plants (e.g. *Pachytheca*) and metazoans like phyllocarids, graptolites.

Via this approach, fossils from Cambrian and Silurian clastic sediments have been studied. The recovered fossils include algal and plant remains, sponge spicules, tentaculites, and cuticles of phyllocarids. The goal of this study is to get new information on the morphology and structure of the higher mentioned fossil remains and better understanding of the link between macrofossil and microfossil record.

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References:

Butterfield, N. J. & Harvey, T. H. P., 2012: Small carbonaceous fossils (SCFs): A new measure of early Paleozoic paleobiology. *Geology,* 40, 1., 71 – 74.

Gensel, P. G., Johnson, N. G. & Strother, P. K., 1990: Early Land Plant Debris (Hooker's "Waifs and Strays"?). *Palaios,* 5, 6, 520 – 547.

SCF IN LOWER PALAEOZOIC SEDIMENTS OF THE BARRANDIAN AREA

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Small carbonaceous fossils (SCFs) is a methodological term, describing fossils that are *"too small to be identified on bedding surfaces, but larger and more delicate than those typically recovered by conventional palynological processing"* (Harvey & Pedder, 2013, p. 278). For the extraction of SCFs, the "low-manipulation HF extraction" method is commonly utilized (Butterfield & Harvey, 2012).

As SCFs have only been recognized several years ago, no systematic study of these fossils has been previously conducted in the Czech Republic. Therefore, twenty-two samples of fine-grained siliciclastic rocks from ten stratigraphic levels of Cambrian, Ordovician and Devonian of the Barrandian area were processed by the "low-manipulation HF extraction" method and subsequently analyzed to test the applicability of the method in the area.

The study (Kovář, 2020) has demonstrated the potential of the method to expand the knowledge of fossil record. Alongside acritarchs, prasinophytes, spores and chitinozoans, various more delicate fossils were recovered, including wiwaxiid sclerites, tentative metazoan mouthparts, and acritarch clusters. Moreover, it has been demonstrated that the method can also be utilized for extraction of some originally calcareous fossils (e.g. tentaculites).

References:

Butterfield, N. J. & Harvey, T. H. P., 2012: Small carbonaceous fossils (SCFs): A new measure of early Paleozoic paleobiology. *Geology*, 40, 1, 71 – 74.

Harvey, T. H. P. & Pedder, B. E., 2013: Copepod mandible palynomorphs from the Nolichucky Shale (Cambrian, Tennessee): Implications for the taphonomy and recovery of small carbonaceous fossils. *Palaios* 28, 5., 278 – 284.

Kovář, V., 2020: SCF in Lower Palaeozoic sediments of the Barrandian area. *MSc. Thesis, Charles University, Czech Republic, 95 pp.*

MAASTRICHTIAN TO PALAEOGENE FORAMINIFERA FROM THE ROPIANKA FORMATION IN THE MARGINAL PART OF THE SKOLE NAPPE (OUTER CARPATHIANS, POLAND)

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Deposits of the Ropianka Formation (also known as the Inoceramian Beds) in the Skole Nappe, Outer Carpathians, provide an insight into stratigraphic record and palaeoenvironmental changes through the K-Pg boundary interval. Studies in the area are mainly based on the Cretaceous planktonic index foraminifera, such as *Abathomphalus mayaroensis* (Bolli), *Contusotruncana contusa* (Cushman) and *Racemiguembelina fructicosa* (Egger). Occasionally, they are supported by the nannofossil analyses.

In this research, foraminifers from two sections at Chodakówka (GPS coordinates of the beginning of the first section: 49°58.810′N, 22°19.644′E; beginning of the second section: 49°58.766′N, 22°19.293′E) and one section at Sietesz (GPS coordinates of the beginning of the section: 49°58.567′N, 22°20.088′E) have been analyzed in 54 samples from isolated outcrops spread along three unnamed creeks. The sections are located in the northernmost part of the Skole Nappe, just nearby the main Carpathian thrust and are composed mainly of deep-sea marly mudstones, fine-grained sandstones and non-calcareous mudstones (variegated shales).

The sections at Chodakówka and Sietesz start with assemblages distinctive of the Maastrichtian in the northern part of the Skole Nappe. Samples contain the diagnostic planktonic taxa of the *A. mayaroensis* Biozone characteristic of the Tethyan domain (Sliter, 1977), i.e. *A. mayaroensis*, *Globotruncanita stuarti* (de Lapparent), *G. stuartiformis* (Dalbiez), *C. contusa*, *R. fructicosa*. However, the Maastrichtian assemblages are mainly composed of 63 µm-size fraction, poorly preserved calcareous benthic forms which include *Anomalina* sp., *Anomalinoides* sp., *Cibicides* sp., *Cibicidoides* sp., *Gavelinella* sp., *Osangularia* sp., and epipelagic forms, such as *Globigerinelloides* sp., *Guembelitria* sp., hedbergelliids, and heteroheliciids. Throughout the Maastrichtian part of the sections, major fluctuations of planktonic to benthic forms ratios are observed. The qualitative and quantitative improvement of the assemblages near the K-Pg boundary, which is distinctive for the region, is also noted.

The agglutinated taxa in the Maastrichtian part of the section, if present, do not exceed 35 % of the benthic group. However, in the middle of the Chodakówka sections the assemblages change rapidly from the dominated by planktonic and benthic calcareous forms to the assemblages almost entirely composed of agglutinated taxa, which occasionally co-occur with poorly preserved or very small-sized benthic calcareous foraminifera. In other words, the Cretaceous planktonic index species disappear in favor of the DWAF assemblages. The shift is generally associated with the K-Pg boundary. In one sample located in the critical interval of change, abundant *Remesella varians* (Glaessner) appears. It may indicate the *R. varians* Interval Zone *sensu* Bąk (2004), which was distinguished in the upper Maastrichtian flysch deposits of the Dukla Nappe (Carpathians). Above that sample, FO of *Rzehakina fissistomata* (Grzybowski) is noted. This species is present throughout the remaining parts of the sections. It most likely belongs to the early Paleocene *Rzehakina fissistomata* Partial Range Zone *sensu* Geroch & Nowak (1984). Other agglutinated foraminifera of the Maastrichtian–Palaeogene intervals, include *Ammodiscus* sp., *Ammolagena clavata* (Jones and Parker), *Ammosphaeroidina* sp., *Caudammina* sp., *Conglophragmium* sp., *Glomospira* sp., *Hormosina velascoensis* (Cushman), *Kalamopsis grzybowskii* (Dylążanka), *Karrerulina* sp., *Nothia* sp., *Paratrochamminoides* sp., *Recurvoides* sp., *Rhabdammina* sp., and *Saccamina* sp. The assemblages are dominated by epifauna-shallow infauna morphotypes, which mostly belong to the M2a, M2b and the M3a morphogroups (Kaminski and Gradstein, 2005).

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References:

Bąk, K., 2004: Deep-water agglutinated foraminifera changes across the Cretaceous/Tertiary and Paleocene/Eocene transitions in the deep flysch environment; eastern Outer Carpathians (Bieszczady Mts, Poland). *In:* Bubík, M. & Kaminski, M. A. (eds.), 2004: Proceedings of the Six International Workshop on Agglutinated Foraminifera. *Grzybowski Foundation Spec. Publ.*, 8, 1 – 56.

Geroch, S. & Nowak, W., 1984: Proposal of the zonation for the Late Tithonian–Late Eocene based upon areaceous foraminifera from the outer Carpathians. *Benthos '83: 2nd Int. Symp. on Benthic Foraminifera (Pau, April 1983)*, 225 – 239.

Kaminski, M. A. & Gradstein, F., 2005: Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera. *Grzybowski Foundation Spec. Publ.*, 10, 547 pp.

Sliter, W. V., 1977: Cretaceous Foraminifers from the Southwestern Atlantic Ocean Leg 36, Deep Sea Drilling Project. *Initial Reports of the Deep Sea Drilling Project,* 36, 519 – 573.

RETIOLITES (GRAPTOLITHINA) AS AN INDICATOR OF CHANGES IN THE SILURIAN MARINE ENVIRONMENT

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Graptolites (Hemichordata) were one of the first free floating organisms widespread around the world. These outstanding colonial organisms, despite of the great opportunity to adapt to drastic environmental changes, become extinct in early Carboniferous. Among the planktic graptolites was a unique group, the biserial retiolitids which evolved through about 20 Ma of the Silurian, from the Aeronian to the Ludfordian periods (Bates et al., 2005). In recent decades, the Silurian emerged as a time frame during which significant changes to the marine environment and biodiversity took place, including several major extinctions. The most dramatic reduction of graptolite diversity was recognized after the mid-Homerian *lundgreni* crisis (Jeppsson & Calner, 2003; Porębska et al., 2004). After that the few species of graptolites survived. Thus, the first retiolitids had massive oval-shaped tubaria (rhabdosomes) with robust apertural hoods adjacent to the apertures, as in *Gothograptus nassa* (Kozłowska et al., 2019). This is considered as an adaptation to the high-energy environment. The great retiolitids re-diversification started in the late Homerian times resulting in lots of new adaptations to the planktic marine life. Numerous forms with various apertural processes extended laterally have appeared. Most of them belong to *Spinograptus* and *Papiliograptus.* One of the recently described retiolitid, the *Papiliograptus retimarginatus* is an example of such adaptation. It had extremely wide genicular processes, distinctively extended laterally from the rhabdosome (Kozłowska & Bates, 2021), opposite to the *Gothograptus*. They were built of some kind of membrane reinforced with edge strips and a delicate mesh formed a continuous surface, to avoid sinking. Therefore the tubarium with large extensions of *Papiliograptus retimarginatus* confirms the suggestions of an adaptation to the quiet environment known in some present day plankton.

References:

Bates, D. E. B. & Kirk, N. H., 1992: The ultrastructure, mode of construction and functioning of a number of Llandovery ancorate diplograptid and retiolitid graptolites. *Modern Geol.,* 17, 1–270.

Bates, D. E. B., Kozłowska, A. & Lenz, A. C., 2005: Silurian retiolitid graptolites: Morphology and evolution. *Acta palaeont. pol.,* 50, 705–720.

Jeppsson, L. & Calner, M., 2003: The Silurian Mulde event and a scenario for secundo-secundo events. *Trans. Roy. Soc. Edinburgh, Earth Sci.,* 93, 135–154.

Kozłowska, A., Bates, D. E. B., Zalasiewicz, J. & Radzevičius, S., 2019: Evolutionary significance of the retiolitine *Gothograptus* (Graptolithina) with four new species from the Silurian of the East European Platform (Baltica), Poland and Lithuania. *Zootaxa*, 4568, 435–469.

Porębska, E., Kozłowska-Dawidziuk, A. & Masiak, M., 2004: The *lundgreni* event in the Silurian of the East European Platform, Poland. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 213, 271–294.

MIDDLE JURASSIC HIATUS CONCRETIONS IN TEMPESTITES OF THE HIMALAYAN TETHYS (THAKKHOLA, NORTHERN CENTRAL NEPAL)

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On the Wikipedia website (https://en.wikipedia.org/wiki/Concretion#Hiatus_concretions) one can find a general definition, short description and explanation of the origin of hiatus concretions: *Hiatus concretions are distinguished by their stratigraphic history of exhumation, exposure and reburial. They are found where submarine erosion has concentrated early diagenetic concretions as lag surfaces by washing away surrounding fine-grained sediments (Zatoń, 2010). Their significance for stratigraphy, sedimentology and paleontology was first noted by Voigt who referred to them as Hiatus-Konkretionen (Voigt, 1968). "Hiatus" refers to the break in sedimentation that allowed this erosion and exposure. They are found throughout the fossil record but are most common during periods in which calcite sea conditions prevailed, such as the Ordovician, Jurassic and Cretaceous. Most are formed from the cemented infillings of burrow systems in siliciclastic or carbonate sediments*.

The Late Triassic – Early Cretaceous sedimentary sequence of the highest tectonic unit of the Himalayas, the so-called "Series (zone) of the Himalayan Tethys" (or "Tibetan Tethys"/"Tibetan sediment zone") palaeogeographically represents the northern Peri-Gondwana margin. In the Thakkhola region (upper part of the Kali Gandaki valley of northern central Nepal) the uppermost Triassic – Late Jurassic sequence is documented by deepening upward deposits follow by the Early Cretaceous regressive cycle. The Triassic-Jurassic part is composed of fluvial-paralic sediments of the latest Triassic, deposits of carbonate platform of the Early and Middle Jurassic, and the Late Jurassic black organic shales with abundant ammonites (the famous Spiti Shales – Nupra Formation) (Gradstein et al., 1989, 1991; Upreti & Yoshida, 2005; Krobicki et al., 2020). One of the best places for stratigraphic-sedimentological analysis of the middle, carbonate part of this sequence is located between Jomosom and Kagbeni villages along the Kali Gandaki valley. The Early Jurassic (Pliensbachian – Early Toarcian) Jomosom Formation (= Kioto Formation) is represented by extremely shallow-marine/lagoon palaeoenvironments of oolitic (with cross-bedding structures) and oncolitic limestones, including recently discovered biostromes of *Lithiotis*-type bivalves. The overlying Middle Jurassic (Bajocian – lowermost Callovian) carbonate deposits of the Bagung Formation is built of thin- and medium-bedded limestones, rich in fossils of benthic fauna – including bivalves (mainly oysters), echinoderms (especially crinoids) and gastropods, which in some places form shell beds/coquinas. Their sedimentological character clearly indicates storm conditions (sharp base with lithoclasts and shell fragments – mainly bivalves, with their gradation/fractionation up to the micritic limestones in the topmost part of these beds) and points out to the shallow-water sedimentation of repeated storm events that create classic limestone tempestites (cf. Aigner, 1985). Different kinds of bivalves (oysters mainly) are coquina-constructed tempestites and hiatus concretions occur mainly within the most thick shell bed (up to 1.5 m) in the middle part of the Bagung Formation. The average dimension of these concretions are 5 – 7 cm. They are characterized by round/oval shape with numerous borings all over their surface that are mainly made by bivalves (*Gastrochenolites*-like) and polychaetes (*Meandropolydora*-like). Hiatus concretions were originated in host sediments (carbonate/shale in character), then were eroded/ exhumated, borred, reworked and resedimented during multi-phase events of tempestite sedimentation and therefore they perfectly document storm-generated origin.

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References:

Aigner, T., 1985: Storm Depositional System. Dynamic Stratigraphy in Modern and Ancient Shallow-Marine Sequences. *Berlin, Springer-Verlag*, 1 – 174.

Gradstein, F. M., Gibling, M. R., Sarti, M., Von Rad, U., Thurow, J. W., Ogg, J. G., Jansa, L. F., Kaminski, M. A. & Westermann, G. E. G., 1991: Mesozoic Tethyan strata of Thakkhola, Nepal: evidence for the drift and breakup of Gondwana. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 88, 193 – 218.

Krobicki, M., Starzec, K. & Paudyal, K., 2020: Early Jurassic (Pliensbachian – Early Toarcian) *Lithiotis*-facies bivalve buildups within Late Triassic – Late Jurassic sequence in the Himalayan Tethys (central Nepal, Thakkhola, Kali Gandaki valley) – stratigraphy, palaeoecology and palaeobiogeography. *The Fourth International Congress on Geosciences of Myanmar and Surrounding Regions* plus IGCP 668 & IGCP 679, Abstracts; 7 & 8, January, 2020, Yangon, Myanmar, 68 – 69.

Upreti, B. N. & Yoshida, M., 2005: Guidebook for Himalayan trekkers. Ser. 1, Geology and Natural Hazards along the Kaligandaki Valley, Nepal. Department of Geology, Tri-Chandra Campus, Tribhuvan University, Kathmandu, Nepal, 1 – 165.

Voigt, E., 1968: Über-Hiatus-Konkretion (dargestellt an Beispielen aus dem Lias). *Geol., Rdsch.,* 58, 281 – 296.

Zatoń, M., 2010: Hiatus concretions. *Geol. Today,* 26, 5, 186 – 189.

THE DISASTER FAUNA OF THE DEVONIAN-CARBONIFEROUS BIOTIC CRISIS PRESERVED IN MICROBIAL LIMESTONES FROM THE MORAVIAN KARST, CZECH REPUBLIC

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The Hangenberg Biotic Crisis at the Devonian/Carboniferous boundary can be regarded as a first order mass extinction; however, the overall palaeobiodiversity loss estimations show that its consequences were milder than those of the other “Big Five” mass extinctions. On the other hand, the profound changes it brought to the communities of primary producers (phytoplankton blackout) and carbonate factories (reinstatement period longer than the recovery time after the Permian-Triassic biocrisis) make it one of the most important milestones in the evolution of the global ecosystems (e.g., Kaiser et al., 2016). The record of the Hangenberg Biotic Crisis can be subdivided into three intervals, comprising the hypoxic Hangenberg Black Shale Event (the main mass extinction phase), the regressive Hangenberg Sandstone Event, and the Stockum Limestone Event. The complete succession of the Hangenberg biocrisis is recorded in the Líšeň Fm in the Moravian Karst, north-east to Brno city, Czech Republic. The Moravian Karst is outcrop of the Palaeozoic sedimentary cover of the Brunovistulian Terrane (southern Laurussian margin during Devonian and early Carboniferous). The Hangenberg Black Shale Event is represented by peculiar laminated limestone (“laminite”) which is well exposed in Brno-Líšeň and its vicinity.

The laminite is approximately 0.5 to 1.0 m thick dark grey microbial bindstone, intercalated by thin turbiditic layers (peloidal grainstone and bioclastic packstone). The microbial origin of the bindstone has been revealed by petrographic study as well as by its geochemical (REE) signature, and represents anachronistic facies related to the mass extinction (Kalvoda et al., 2018). Several redox proxies (Mo_{EF}, U_{EF}, U/Th, framboidal pyrite) have showed fluctuations between oxic to euxinic conditions during laminite deposition (Kalvoda et al., 2018; Kumpan et al., 2019). The laminite yielded low-diversity macrofaunal association at two sites in the

Brno-Líšeň (Říčka Brook Valley and Líšeň-Hřbitov). The most abundant macrofossils are ammonoids and bivalves. The determinable ammonoids belong to the clymeniid species *Postclymenia* cf. *evoluta*. Isolated articulated jaws of this cephalopod are highly abundant in several levels of the laminite, as well as dissolved and compacted conchs. Additionally, a single conch of undeterminable tornoceratid goniatite has been found. Bivalves are articulated and belong to *Guerichia* sp., and probably also to other taxa. Besides these mollusks, also bryozoan colony encrusting *Postlymenia* conch, single complete carapace of thylacocephalan arthropod *Concavicaris* sp., and undeterminable ichthyoliths have been found. Microfossils from the insoluble residuum are rather scarce, comprising rare conodonts (*Polygnathus communis communis*, and several ramiform specimens). Radiolarians are the most abundant bioclasts observed in thin sections.

Deposits of the Hangenberg Black Shale Event are usually fossil free worldwide; therefore, fossiliferous rocks from this time interval are rare and highly important. The macrofossils association with gueirichids and *Postclymenia* cf. *evoluta* has been reported from the type litostratigraphic unit of the event, the Hangenberg Black Shale from the Rhenish Slate Mts. (Laurussia; Becker et al., 2021). The association highly similar to the Moravian one has been documented from the Hangenberg Black Shale equivalent in the Ma'der region, Morocco (Gondwana; Klug et al., 2016), involving also ammonoids encrusted by bryozoan colonies and ichthyolites. This low-diversity association represents cosmopolitan disaster fauna with predominance of nektonic groups, due to the global benthic dysoxia, symptomatic for the Hangenberg Black Shale Event. Abundant occurrence of gueirichid bivalves could be related to short episodes of oxygenation triggered by turbiditic currents (Kalvoda et al., 2018; Kumpan et al., 2019), or to their possible pseudoplanktic lifestyle. Conspicuous is abundant occurrence of cephalopod jaws in the Moravian Karst and Ma'der. Anaptychi are well known from the Frasnian, but the Famennian cephalopod jaws record is very scarce, restricted to Ohio (Frye and Feldmann, 1991), lower part of the upper Famennian in the Rhenish Massif (Korn, 1994), and Ma'der only (Klug et al., 2016). The reported jaws from the Moravian Karst are the first Laurassian record from the uppermost Famennian.

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References:

Frye, C. J. & Feldmann, N. R. M., 1991: North American Late Devonian cephalopod aptychi. *Kirtlandia*, 46, 49–71.

Kaiser, S. I., Aretz, M. & Becker, R. T., 2015: The global Hangenberg Crisis (Devonian–Carboniferous transition): review of a first-ordermass extinction. In: Becker, R.T., Königshof, P., Brett, C. E. (Eds.): *Devonian Climate, Sea Level and Evolutionary Events,* 423. Geol. Soc., London, Spec, Publ., 387–439.

Kalvoda, J., Kumpan, T., Holá, M., Bábek, O., Kanický, V. & Škoda, R., 2018: Fine-scale LA-ICP-MS study of redox oscillations and REEY cycling during the latest Devonian Hangenberg Crisis (Moravian Karst, Czech Republic). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 493, 30–43.

Klug, Ch., Frey, L., Korn, D., Jattiot, R. & Rücklin, M., 2016: The oldest Gondwanan cephalopod mandibles (Hangenberg Black Shale, Late Devonian) and the mid-Palaeozoic rise of jaws. *Palaeontology*, 59, 611–629.

Korn, D., 2004: Late Famennian cephalopods from the Refrath 1 Borehole (Bergisch Gladbach-Paffrath Syncline; Ardennes-Rhenish Massif, Germany). *Cour. Forsch.-Inst. Senckenberg*, 251, 175–183.

Kumpan, T., Kalvoda, J., Bábek, O., Holá, M. & Kanický, V., 2019: Tracing paleoredox conditions across the Devonian-Carboniferous boundary event: a case study from carbonate-dominated settings of Belgium, the Czech Republic, and northern France. *Sedimentary Geol.,* 380, 143–157.

PALAEOVEGETATION AND PALAEOENVIRONMENT OF THE BOHEMIAN CENOMANIAN

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Plant fossils from the Peruc-Korycany Formation of the Bohemian Cretaceous Basin are known for more than 200 years. Most of the material comes from the fluvial and estuarine strata of middle Cenomanian as indicated by presence of index amonite *Acanthoceras jukes-brownei* (e.g. Čech et al., 2005). However, the oldest known sediments of the Formation occur in the Blansko Graben. They are assigned to palynozone *Retitricolpites georgensis-Dicotetradites* sp., that is compared to the upper Albian and lower Cenomanian of the Raritan Formation in New Jersey (Svobodová & Brenner, 2000).

In the Bohemian Massif the Cenomanian Peruc Korycany Formation is exposed in several quarries and number of natural exposures. In some places, especially in the Pecínov quarry W of Prague, the Cenomanian succession was studied in multi-disciplinary studies providing major frame for our studies (Uličný et al., 1997). Ongoing research provides new insights into the relationship between localities and their palaeovegetation and palaeoenvironment. General overview of the major plant assemblages of the Peruc Korycany Formation is the major topic of the presented contribution showing palaeovegetation and the regional palaeoenvironmental conditions throughout the Cenomanian transgression.

Based on studies of more than twenty localities five major plant vegetation types are distinguished:

Salt marsh environment hosted an association dominated by *Frenelopsis alata*, the cheirolepidiaceous conifer and ginkgophytes (*Nehvizdyella bipartita*, *Eretmophyllum obtusum)*. Angiosperms *"Diospyros" cretacea* and herbaceous *Pseudoasterophyllites cretaceus* growing in open areas, were common accessories there.

Palynological assemblage is characterized by dominance of gymnosperm pollen and fern spores. Significant feature is the occurrence of *Classopollis* pollen. Angiosperms occur only accessorily. Marine influence is documented by acritarchs, chitinous linings of foraminifers and fragments of dinocysts.

Freshwater, wetland plant associations

Braided river flood plain association from Pecínov, Brtev, Perálec was dominated by lauroid angiosperms (*Mauldinia bohemica*, *Pragocladus lauroides*), more stable parts of flood plain hosted Gleicheniaceae ferns, cycads (*Nilssonia holyi*) and angiosperms (*Ettingshausenia laevis*, *Dicotylophyllum* sp. A, B, D).

Palynological assemblage is dominated by a well-preserved angiosperm pollen, dicotyledonous small tricolpate reticulate grains of *Retitricolpites exiquiexemplum,* periporate *Bohemiperiporis zaklinskai* and psilate triangular tricolporate pollen of *Perucipollis minutus.* and monosulcate reticulate forms of *Liliacidites* spp. Only few specimens of pteridophyte spores of the Cyatheaceae and Lycopodiaceae families appear.

Meandring river flood plain association from Vyšehořovice, Horoušany, Břežany was dominated by platanoid (*Ettingshausenia bohemica*) and lauroid (*Myrtoidea geinitzii*) angiosperms in understorey hosting lycopods (*Selaginella cretacea*), ferns (*Cladophlebis frigida*, *Protopteris punctata*) and cycads (*Microzamia gibba*, *Jirusia jirusii*).

Palynospectrum is dominated by diverse angiosperm species, moreover first biostratigrafically important triporate pollen from the Normapolles group – *Complexiopollis* spp. appear. Pteridophyte spores belong to the families Lycopodiaceae, Schizaeaceae, Gleicheniaceae and Cyatheaceae. Gymnosperm pollen is represented by the Cupressaceae and Cycadaceae families.

Coastal swamp association from Praha-Hloubětín-Hutě, Pecínov was dominated by cupressoid conifers (*Cunninghamites lignitum, Quasisequoia crispa, Elatocladus velenovskii*) with lycopods and ferns in understorey.

Palynologic assemblage is dominated by Lycopodiaceae spores and gymnosperm pollen of the Cupressaceae family.

Upland plant associations from Praha, Malá Chuchle, Bohdánkov, Pecínov were dominated by ferns (*Konijnenburgia*), cycads (*Psudoctenis pecinovensis, Nilssonia mirovanae*), bennettits (*Cycadeoidea* sp., *Zamites bayeri*), Caytoniales (*Sagenopteris variabilis*) and araucarioid conifers (*Dammarophyllum striatum, Brachyphyllum squamosum*). Shruby angiosperms were particularly common on slopes of the rivers (*Araliphyllum dentiferum*, *Debeya coriacea*, *Dicotylophyllum labutae*).

Palynological assemblage is characterize by prevailing pteridophyte spores, some ephedroid gymnosperm pollen *Ephedripites* sp., *Vitreisporites pallidus* (Caytoniaceae), possible representatives of Bennettitales – *Ginkgocycadophytus nitidus.*

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References:

Čech, S., Hradecká, L., Svobodová, M. & Švábenická, L., 2005: Cenomanian and Cenomanian-Turonian boundary in the southern part of the Bohemian Cretaceous Basin, *Czech Rep. Bull. Geosci.*, 80, 321 – 354.

Svobodová, M. & Brenner, G. J., 2000: Correlation of mid-Cretaceous plant microfossils from the Raritan Formation of the Atlantic Coastal Plain with the Peruc-Korycany Formation of the Blansko Graben. *Acta Palaeobot., Suppl*. 2, 199 – 209.

Uličný, D., Kvaček, J., Svobodová, M. & Špičáková, L., 1997: High frequency sea-level fluctuations and plant habitats in Cenomanian fluvial to estuarine succession: Pecínov quarry, Bohemia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 136, 165 – 197.

CHANGE IN A COMPOSITION OF THE AMPHIBIAN FAUNA FROM THE LOWER PERMIAN LETOVICE FORMATION (BOSKOVICE BASIN, CZECH REPUBLIC)

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The Boskovice Basin is renowned due to hundreds of very well preserved Lower Permian discosauriscid and temnospondyl amphibians. Most finds are known from the Letovice Formation of Asselian age (Opluštil et al., 2017), eventually Asselian to Sakmarian age (Štamberg & Zajíc, 2009). The first described discosauriscid amphibian in Boskovice Basin comes from the Malá Lhota locality (Makowsky, 1876). Temnospondyls were documented only much later (Augusta, 1947). Note, however, that the reason for this apparent lack of interest in this extinct group might very likely reflect the incorrect classification as temnospondyls were usually included in to the same group with discosauriscids (for ex. Phylospondyli, Branchiosauria).

During the last two decades, there is an increase of interrest in temnospondyls from this area and several taxa have been described so far (Milner et al. 2007, Klembara & Steyer, 2012). Besides them, undescribed specimens (probably belonging to eryopids and amphibamids) exist, being known from the Middle Letovice Member. Additionally, there are also newly found specimens of stereospondylomorphs and branchiosaurids from Lower Letovice Member.

The occurrence of temnospondyls in the fossil record suggests a higher diversity of amphibians in the Lower Permian lake of the Boskovice Basin than previously thought. Moreover, there are differences between amphibian faunas from the Lower and Middle Letovice Member which cannot be explained by taphonomic and/or sampling biases. The amphibian record from the Lower Letovice Member consists of rich finds of both temnospondyls (branchiosaurids and stereospondylomorphs) and discosauriscids. Contrary to that, the Middle Letovice Member is dominated by discosauriscids, whereas temnospondyls are rare here (zatracheids, eryopids?, amphibamids?, branchiosaurids). It is very likely that this change in amphibian faunas in Letovice Formation was caused by the aridization of the paleoenvironment. Similar changes which have been caused by aridization have also been described in the plant communities of the Boskovice Basin (Opluštil et al., 2017). Moreover, differences between Lower and Middle Letovice Member are also reported on fish fauna (Štamberg & Zajíc, 2009).

References:

Makowsky, A., 1876: Über einen neuen Labyrinthodonten ‘Archegosaurus austriacus nov. spec.’ *Sitz.-Ber. K. Akad. Wiss.,* 73, 155–166.

Augusta, J., 1947: Spodnopermská zvýřena a květena z nového naleziště za pilou “Antonín” u Zbýšova na Moravě. *Věst. St. geol. Úst. Republ. čs.,* 22, 187–224.

Milner, A. R., Klembara, J. & Dostál, O., 2007: A zatrachydid temnospondyl from the lower Permian of the Boskovice Furrow in Moravia (Czech Republic). *J. Vertebr. Paleont.,* 27, 11–715.

Klembara, J. & Steyer, J. S., 2012: A new species of Sclerocephalus (Temnospondyli: Stereospondylomorpha) from the early Permian of the Boskovice Basin (Czech Republic). *J. Paleont.,* 86, 302–310.

Opluštil, S., Jirásek, J., Schmitz, M. & Matýsek, D., 2017: Biotic changes around the radioisotopically constrained Carboniferous-Permian boundary in the Boskovice Basin (Czech Republic). *Bull. Geosci.,* 92, 1, 95–122.

Štamberg, S. & Zajíc, J., 2009: Carboniferous and Permian faunas and their occurence in the limnic basins of the Czech Republic. *Hradec Kralové, Muzeum vychodních* Čech v Hradci *Kralové,* 224 pp.

GEOARCHEOLOGY RESEARCH OF PODKOVICA SITE AND VEĽKÝ JAROK IN MORAVANY NAD VÁHOM (SLOVAK REPUBLIC) DURING PLENIGLACIAL (MIS 4 TO MIS 2)

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Studied localities are situated on the western slopes of the Považský Inovec Mts., near the village Moravany nad Váhom. The Paleolithic site in Moravany nad Váhom-Podkovica is located in the north-eastern part of the "Moravany settlement area" and is among the most famous Upper Palaeolithic sites in Slovakia. Second studied locality – Veľký jarok is located about 80 m from the well-known Hlboký jarok – an erosive furrow in loess sediments and about 1 km from Podkovica site.

Podkovica site: The aim of new field researchs in Podkovica site was looking for old trenches and in situ archaeological layer, reexamination of cultural layers, new interdisciplinary excavations with multiproxy approach, paleontological research, geological survey and geochronology, palaeoecological reconstuctions. During field work an anthropogenic layer with scattered lithic artefacts, faunal remains, ash, charcoals, burned stones and mineral dyes has been identified. By this research we documented the first evident anthropogenic "structure" at the site and confirmed by modern research methods. It is possible to interpreted it as a pit or hearth, or a combination of both. The result of the first bone charcoal dated using the C14 method corresponds to a post Last Glacial Maximum date (MIS 2): 25 620 – 23 406 and 22 496 – 19 160 cal. yBP. The faunal remains from the 2019 trench are from various species: reindeer, hare and mammoth, which are typical of local biota and correspond to the climatic conditions and development of the local environment during LGM.

Veľký jarok: The research of the loess profile was focused on the spatio-temporal development of the paleoenvironment during the Lower and Middle Pleniglacial. We focused on detailed and complex stratigraphic, sedimentary, geochemical, paleontological, isotope and climatic research. The loess-paleosol record at this important Quaternary site provides an excellent high-resolution archive of climate and environmental changes. Veľký jarok represent a significant and unique climatic-sedimentary record of Central Europe.

No one has dated this loess profile numerically so far. Loess sedimented during the Lower and Middle Pleniglacial (MIS 4, MIS 3) on the base of OSL dating. The beginning of sedimentation of the lower layer of the loess profile began around 61 300 (± 3 300) (GdTL-3 207) yBP. The top layer of the loess profile sedimented in the period around 42 500 (± 2 100) (GdTL-3 208) yBP.

Stable isotope research of malacofauna and pedogenic carbonates confirm significant paleotemperature changes during the Lower and Middle Pleniglacial on this loess profile. The paleotemperature in the studied profile was colder than the temperature average at present. Stable isotope analyses of oxygen from shells characterize the malacofauna as communities resistant to glacial and/or stadial conditions in the lower part of the profile – about 61 300 yBP. Malacofauna on the upper part of the profile – about 42 500 yBP is characterised as cryophilic communities of snails preferring stadial conditions on the base of oxygen isotope analyses. This conclusion is also supported by the malacofauna analysis, which characterizes environment as an open landscape – loess steppe at the beginning of sedimentation of the studied loess. Gradually, the environment changed to an open landscape, with a small representation of forests near the aquatic environment. The character of the locality reflects its location on the edge between the foothills of Považský Inovec Mts. and the river Váh floodplain. Meandering river has always a significant impact on the microclimatic development of the studied locality and its surroundings.

The complex of Paleolithic settlements in the vicinity of Moravany nad Váhom lying in the loess represent one of the most promising regions for Paleolithic research in Slovakia with European significance. And therefore it is very important and necessary to continue fieldwork to enlarge the currently explored area and run a systematic study of the geochronology and loessic profiles of the region.

References:

Hromadová, B., Nemergut, A, Klaric, L., Moravcová Ábelová, M. & Vlačiky, M., 2021: Výsledky revízneho výskumu mladopaleolitickej lokality v Moravanoch nad

Váhom-Podkovici (Slovenská republika). Revision excavations of the Upper Palaeolithic site in Moravany nad Váhom-Podkovica (Slovak Republic). *Přehl. výzk.,* 62/1, 2, accepted manuscript (in press).

Šefčík, P., Moravcová, M. & Demko, R., 2019: Klimatostratigrafia, paleoenvironmentálny vývoj a izotopová analýza významných kvartérnych lokalít Slovenskej republiky. Čiastková správa k záverečnej správe geologickej úlohy Výskum geologickej stavby a zostavenie geologických máp v problematických územiach Slovenskej republiky. *Manuscript. Bratislava, archive St. Geol. Inst. D. Štúr,* 149 pp.

MIDDLE JURASSIC VEGETATION AND PALAEOECOLOGY IN THE KANSK BASIN, SIBERIA

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The Jurassic flora of the Kansk coal basins nowadays is deeply studied in terms of palaeobotany, systematic of plants and phytostratigraphy as well thanks to exploration geology. However palaecological implications of vegetation is slightly out of agenda so far. In this report we focused on palaeoecological studies of terrestrial deposits in the Kamala Formation of Rybnaja structure-facies zone. Studied materials are represented by imprints, sporadic petrifications and dispersed cuticles that consisted of a number of hand specimens. Monographical descriptions of plant remains and lithofacial analysis of the Kamala Formation among Rybnaja river valley were carried out. Derived data was compared with palaeocological conditions of terrestrial units in the Middle Jurassic of the West Siberia. Consequently, plant assembly is composed of horsetails [*Equisetites laterals* (Phill.) Phill., *Equisetites beanie* (Bunb.) Sew., ferns (*Coniopteris hymenophylloides* (Brongn.) Sew., *Coniopteris* sp., *Cladophlebis haibunensis* (Lindl. et Hutton) Brongn., *Cladophlebis* cf. *multinermus* Golova, ginkgoaleans (*Sphenobaiera* sp., *Ginkgo* cf. *capillata* Kiritchk. et Kostina, *Ginkgo* sp., *Eretmophyllum* sp.), czekanowskialeans (*Czekanowskia rigida* Heer, *Cz. mchatika* Kirichk. et Samyl., *Phoenicopsis angustifolia* Heer] and number of plant remains of uncertain systematic affinity as roots and stem fragments. Floristic composition with high dominance of gymnosperms, particularly from the order Czekanowskiales, presence of temperate species and lack of thermophilic plants, indicating cold temperate conditions of environment. The systematic diversity of the vegetation demonstrates that it is referred to Coniopteris-Phoenicopsis or Siberian flora defined by Vakhrameev V. A., and resemble in plant diversity the lower and middle parts of the Tyumen Formation in the West Siberia.

References:

Kostina, E. I., 2004: Jurassic flora of the Kansk Coal Basin. *Moscow, GEOS,* 166 p.

Wang, Y.-F., Li, H., Dilcher, D. L., Bugdaeva, E., Tan, X., Li, T., Na, Y.-L. & Sun, C.-L., 2019: Middle Jurassic Plant Diversity and Climate in the Ordos Basin, China. *Paleont. J.,* 53, 11., 1216–1235.

ASSESSING TEST ULTRASTRUCTURE OF CHITINOIDELLIDS AND CALPIONELLIDS FROM THE UPPER JURASSIC AND LOWER CRETACEOUS PELAGIC DEPOSITS OF THE PIENINY KLIPPEN BELT (WESTERN CARPATHIANS)

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Calcareous microplankton such as chitinoidellids and calpionellids became abundant and even rock-forming during the latest Jurassic, partly coinciding with the increase in abundance of calcareous nannoplankton and with the onset of deposition of biancone and maiolica sediments. However, environmental causes driving their appearance, turnover, and the evolutionary shift in the lorica composition from agglutinated (microgranular) to calcitic (hyaline) walls remain poorly understood.

The ultrastructure of chitinoidellid and calpionellid loricae in pelagic sediments of the Western Carpathians was evaluated by Reháková & Michalík (1993) on the basis of scanning electron microscopy (at > 2,000x magnification). They documented that chitinoidellid loricae (genus *Chitinoidella*) are formed by tiny rhombohedral transversaly oriented calcite crystals embedded in organic cement. They observed that the microgranular layer is rimmed by scalenohedral calcite crystals on both sides of the microgranula layer. These crystals are oriented perpendicularly to the test wall, and were interpreted to be of early-diagenetic origin. In contrast, loricae of calpionellids (*Calpionella*, *Crassicollaria*) consist of relatively-corase calcite crystals with irregular shape and 4–7 μm in size. The surface of those crystals is either corroded and/or overgrown by rhombohedral, early-diagenetic calcite crystals. However, the composition of the loricae of the so-called praecalpionellids that stratigraphically occur on the transition between chitinoidellids and calpionellids remains unknown at high-magnification scales. Interestingly, the loricae of praecalpionellid genera *Praetinnopsella* and *Semichitinoidella* are formed by two layers (Nowak, 1978). The microganular layer is the external layer and the hyaline layer is the internal layer in praetintinnopsellids. In contrast, the hyaline layer is the external layer and the internal layer is microgranular in semichitinoidellids.

The aim of this study is to revisit the ultrastructure, chemical composition, and taphonomy of chitinoidellid and calpionellid loricae, with a special emphasis on the transition between the agglutinated and calcitic loricae that is represented by the two-layer type of praecalpionellids.

The specimens evaluated in our study of the ultrastructure of loricae walls were collected in the Tithonian and Berriasian deposits from the Czorsztyn and Pieniny formations at Brodno and Snežnica sections (Pieniny Klippen Belt).

The electron microprobe revealed that chitinoidellid-like sections from the interval on the transition between the Boneti Subzone and the Crassicollaria Zone at Snežnica possess the microgranular layer (with the thickness of about 5 μm) that is formed by angular needles or plates of low-Mg calcite (consistently < 1 μm). Larger rhombohedral crystals of diagenetic origin are frequently dispersed within this layer and replace the original mesh-like fabric formed by the needles. We did not observe complete nannofossil tests in the micrugranular wall. However, abundant fragments and tests of nannopankton occur in the surrounding matrix. The electron microprobe maps indicate that the content of Mg in the microgranula layer does not differ from the Mg concentrations in the micrite matrix rich in remains of calcareous nannoplankton. It can be hypothesized that the needless in the microgranula layer are derived from fragments of nannoplankton plates (that were agglutinated by organic cement and subsequently partially diagenetically altered).

Scanning electron microscope shows that in chitinoidellids, this microganular layer is enveloped by a thin (2–3 μm-thick) external hyaline-like layer formed by bladed crystal prisms. This external layer can also be visible in BSE images but is less distinct than under SEM owing to the lack of contrast in the chemical composition relative to the surrounding matrix. This type of test thus can be assigned to semichitinoidellids as described by Nowak (1978).

In calpionellids, as expected, the microgranular wall is absent and the lorica is formed by the hyaline layer only. This layer is frequently indistinct in BSE images. However, high-resolution maps show that their walls are consistently enriched in Mg, in contrast to lower concentrations of Mg in micrite. SEM images reveal that the hyaline wall consists of prisms of bladed or fibrous crystals.

References:

Nowak, W. A., 1978: Semichitinoidella n. Ge. (Tintinnina) of the Upper Jurassic of the Czorstyn Succession, Pieniny Klippen Belt (Carpathians, Poland). *Rocz. Pol. Tow. geol., Ann. Soc. géol. Pol.,* XLVIII, 1, 3–25.

Reháková, D. & Michalík, J., 1993: Observation of ultrastructure of the Upper Jurassic and Lower Cretaceous calpionellid test. *Geol. Carpath.,* 44, 2, 75–79.

NEW INFORMATION ON THE OLIGO-MIOCENE SNAKE FAUNA FROM CENTRAL ANATOLIA – A CASE STUDY OF THE KARGI 1, 2 LOCALITIES

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European late Palaeogene snake communities, with dominant Amerophidia (Anilioidea, Tropidophiidae) and small representatives of Booidea, were largely replaced by 'modern' snake clades (Viperidae, Elapoidea, Colubroidea) shortly after the Oligocene/Miocene transition. This replacement, which was nearly finished before the onset of the Miocene Climatic Optimum, is the key part of understanding the origin of modern snake communities in Europe. The well-dated MP 30 to MN 1 localities with diversified snakes only rarely occur in central and eastern/southeastern Europe. However, Anatolian area provided several Oligo-Miocene localities which are of crucial importance for study of colonization of the Balkan Peninsula from southwestern Asia and/or northern Africa. Most of Anatolian amphibian and reptile Cenozoic localities correspond to the Pliocene and Pleistocene age. Older localities also occur in this area despite the fact that Anatolia was affected by the volcanic and tectonic activity in the geological past. Recent research on several Oligocene and Miocene localities from Turkey uncovered the presence of Anguidae (Čerňanský et al., 2017), amphisbaenians are represented by the worm lizard *Blanus* cf. *strauchi* from the Gebeceler Formation, western Turkey (Georgalis et al., 2018). The earliest Miocene Kilçak locality (MN 1) provided amphibian families Salamandridae, Alytidae, Palobatidae and of reptile families Lacertidae, Anguidae (Syromyatnikova et al., 2019). Despite these remarkable discoveries, only a few localities prove the presence of snake fauna in Anatolia. The Kurucan locality (MP 30–MN 1; easternmost Turkey) provided only two vertebrae of *Bavarioboa* sp. (Szyndlar & Hoşgör, 2012). The snake community is much more diversified on Kilçak locality where Aniliidae, Boidae, Tropidophiidae and Colubridae have been reported (Syromyatnikova et al., 2019). This locality is very close to results from the locality of Kargi (MN 30/MN 1 zone), in central Anatolia.

Snake fauna from Kargi localities (Kargi 1–3) is almost unknown. Only *Albaneryx* sp. have been reported from Kargi 3 (Vasilyan et al., 2019). However, its even generic attribution based on one rather fragmentary vertebra is not clear. The localities of Kargi 1 and 2 provided several snake clades including Aniliidae (*Eoanilius* cf. *oligocenicus*), Tropidophiidae (*Falseryx* sp.), Boidae (*Bavarioboa* sp.) and Colubroidea. The trunk vertebrae attributed to *Bavarioboa* differ from other representatives of this genus by the specific morphology of prezygapophysis. The occurrence of the genus *Falseryx* is supported by the presence of caudal vertebrae with simple morphology of the neural arch and a 'hypapophysis' instead of haemapophyses on the ventral surface of the vertebral centrum. Colubroid snakes are represented probably only by a single taxon (Colubroidea morphotype A). However, unusual development of interzygapophyseal ridges differentiates this morphotype from other known European fossil Colubroidea. The presence of taxa which frequently occur in Europe (including central Europe) since the Oligocene (*Eoanilius*, *Falseryx*, *Bavarioboa*) show on frequent exchanges of snake fauna between Anatolia and Balkan Peninsula around the Oligocene/Miocene transition. The origin of colubroid snake reported from in Kargi 1 and 2 is still debated as this rather diversified clade have been also reported from the late Oligocene of Africa (Tanzania, Nsungwe Foramtion; McCartney et al. 2014). Therefore, African origin of this taxon cannot be excluded. This study can help to fill still incomplete knowledge on the origin and evolution of late Cenozoic snake communities of southeastern Europe.

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References:

Čerňanský, A., Vasilyan, D., Georgalis, G. L., Joniak, P., Mayda, S. & Klembara J., 2017: First record of fossil anguines (Squamata; Anguidae) from the Oligocene and Miocene of Turkey. *Swiss J. Geosci.,* 110, 3, 741 – 751.

Georgalis, G. L., Halaçlar, K., Mayda, S., Kaya, T. & Ayaz, D., 2018: First fossil find of the *Blanus strauchi* complex (Amphisbaenia, Blanidae) from the Miocene of Anatolia. *J. Vertebr. Paleont.,* 38, 2.

McCartney, J. A., Stevens, N. J. & O'Connor, P. M., 2014: The Earliest Colubroid-Dominated Snake Fauna from Africa: Perspectives from the Late Oligocene Nsungwe Formation of Southwestern Tanzania. *PLoS ONE* 9, 3: e90415. doi:10.1371/journal.pone.0090415.

Syromyatnikova, E., Georgalis, G. L., Mayda, S., Kaya, T. & Saraç, G., 2019: A new early Miocene herpetofauna from Kilçak, Turkey. *Russ. J. Herpetol.,* 26, 4, 205 – 224.

Szyndlar, Z. & Hoşgör, I., 2012: Boinae snake *Bavarioboa* from the Oligocene/Miocene of eastern Turkey with comments on connections between European and Asiatic snake faunas. *Acta Palaeont. Pol.,* 57, 3, 667 – 671.

Vasilyan, D., Roček, Z., Ayvazyan, A. & Claessens, L., 2019: Fish, amphibian and reptilian faunas from latest Oligocene to middle Miocene localities from Central Turkey. *Palaeobiodivers. Palaeoenviron.,* 99, 4, 723 – 757.

PRELIMINARY RESULTS ON EARLIEST PERMIAN FISH MIGRATION WITHIN THE INTRA-SUDETIC BASIN AND OTHER CENTRAL EUROPEAN LIMNIC BASINS

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Earliest Permian (Asselian) deposits of the Intra-Sudetic Basin comprise up to six basin-wide lacustrine horizons. The facies composition and lateral variability coupled with faunal and floral assemblages provide great opportunity to study environments and their changes through this narrow stratigraphic interval (e.g. Awdankiewicz et al., 2003; Blecha et al., 2008; Burliga et al., 2008; Martinek et al., 2006; Mastalerz & Nehyba, 1997; Nemec, 1981; Opluštil et al., 2016). Understanding of this complex issue is crucial for the improvement of biostratigraphic zonations as well as the recognition of evolutionary processes, shaping the diversity of early Permian continental biota. Due to the abundance of available data, this study is focused on the comparison of Intra-Sudetic Olivětín Member (Słupiec Formation) with contemporaneous fossil-bearing deposits of non-marine Carboniferous-Permian basins of Central Europe. Numerous fossils of xenacanthid chondrichthyans, actinopterygians, and amphibians qualify the Olivětín Member as the richest unit in aquatic vertebrates within the Permian succession of the Intra-Sudetic Basin. The presence of volcanic rocks within the Olivětín Member promise a more precise geochronological framework for the correlation of the lacustrine horizons.

Recent excavations in Janików locality (Poland) yielded 18 articulated specimens of actinopterygians, preserved as laterally compressed individuals in a black, muddy shale. The best preserved specimens show complete postcranial skeletons, whereas cranial portions are rarely and poorly preserved. We assign them to *Paramblypterus* sp. based on postcranial features (scale morphology, scales count, number of fin rays, body proportions). Other, less complete fish fossils from this site exhibit features consistent with the well-preserved specimens, wherefore the ray-finned fish community from Janików is apparently monotypic. Janików represents another Asselian fish assemblage dominated by amblypterids, located in the eastern part of the system of inland Carboniferous-Permian basins in central Europe. In contrast, the roughly contemporaneous assemblages from the western part of this system include more frequent and diverse elonichthyids and sarcopterygians. Currently, we undertake two main possible explanations of this phenomena: different preferences related with depositional settings or association with some climatic factors. The study is going to be continued for comparisons with other Asselian vertebrate-bearing horizons.

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References:

Awdankiewicz, M., Kurowski, L., Mastalerz, K. & Raczyński, P., 2003: The Intra-Sudetic Basin – a record of sedimentary and volcanic processes in late- to post-orogenic tectonic setting. *Geolines,* 16, 165–183.

Blecha, M., Burliga, S., Lojka, R., Martinek, K. & Wojewoda, J., 2008: Osady permskie basenu śródsudeckiego. In: Wojewoda, J. (ed.): Baseny Śródgórskie – Kontekst Regionalny Środowisk i Procesów Sedymentacji, 61–83.

Martínek, K., Blecha, M., Daněk, V., Franců, J., Hladíková, J., Johnová, R. & Uličný, D., 2006: Record of palaeoenvironmental changes in a Lower Permian organic-rich lacustrine succession: Integrated sedimentological and geochemical study of the Rudník member, Krkonoše. Piedmont Basin, Czech Republic. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 230, 1–2, 85–128.

Mastalerz, K. & Nehyba, S., 1997: Comparison of Rotliegendes lacustrine depositional sequences from the Intrasudetic, North-Sudetic and Boskovice basins; Central Europe. *Geol. Sudet.,* 30, 21–57.

Nemec, W., 1981: Tectonically controlled alluvial sedimentation in the Słupiec Formation (Lower Permian) of Intrasudetic Basin. In: International Symposium on Central European Permian, Jabłonna, April 27–29, 1978. *Kraków, Państw. Inst. Geol.,* 294–311.

Opluštil, S., Schmitz, M., Kachlík, V. & Štamberg, S., 2016: Re-assessment of lithostratigraphy, biostratigraphy, and volcanic activity of the Late Paleozoic Intra-Sudetic, Krkonoše-Piedmont and Mnichovo Hradiště basins (Czech Republic) based on new U-Pb CA-ID-TIMS ages. *Bull. Geosci.,* 91, 2, 399–432.

PALAEOENVIRONMENTAL CHANGES AT THE BADENIAN-SARMATIAN BOUNDARY IN THE SE POLISH CARPATHIAN FOREDEEP INFERRED FROM FORAMINIFERS

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The Badenian-Sarmatian (B-S) boundary in Central Paratethys has been traditionally identified by the faunal turnover known as the Badenian-Sarmatian Extinction Event (Harzhauser and Piller, 2007) recording an important environmental change possibly controlled by the change in seawater chemistry (in traditional approach – from marine to brackish conditions; e.g. Śliwiński et al., 2012). The strata below the B/S boundary in the northern Carpathian Foredeep are traditionally included into Pecten beds, and those above it into Syndesmya beds (Pawłowska and Kubica, 1960). Foraminiferal study of the Babczyn 2 borehole (Peryt et al., 2021) which is one of the crucial sections in the northern Carpathian Foredeep, well-known for the depositional age of rhyolite tuff within the Pecten beds dated by Śliwiński et al. (2012) at 13.06 ± 0.11 Ma, indicated that in fact the boundary occurs within the Syndesmya beds.

For the purpose of this paper benthic foraminifer assemblages from the *Hanzawaia crassiseptata*, *Elphidium angulatum* and *Anomalinoides dividens* zones have been studied. More than 45 benthic species were recorded. Benthic assemblages are moderately to highly diversified, and species have more equal frequencies in the *Hanzawaia crassiseptata* Zone; low diversified and almost monospecific are in the *Elphidium angulatum* and *Anomalinoides dividens* zones. Six assemblages have been identified in the discussed interval:

Angulogerina angulosa – Bulimina assemblage in the lower part of the *H. crassiseptata* Zone (samples 15 – 19) characterized by dominance of infaunal, dysoxic taxa forming 51 – 61 % of the assemblage.

Angulogerina angulosa – Melonis pompilioides assemblage in the middle part of the *H. crassiseptata* Zone (samples 20 – 22); in this assemblage at the expense of *Bulimina* increases in abundance *Melonis pompilioides* forming 8 – 17 % of the assemblage; infaunal, dysoxic taxa reach 53 – 80 % of the assemblage.

Heterolepa dutemplei – Sphaeroidina bulloides assemblage in the upper part of the *H. crassiseptata* Zone (samples 23 – 28); the highest diversified assemblage; *S. bulloides* forms 8 – 12 % of the assemblage while *H. dutemplei* 7 – 9 % and the latter one occurs only in this assemblage; contribution of dysoxic species vary from 43 to 64 %.

Elphidium angulatum – Porosononion martkobi assemblage in the lower part of the *Elphidium angulatum* Zone (samples 29 – 31); very low diversity assemblage with common non-keeled elphidiids and rare *Cycloforina* as minor component.

Cycloforina – Quinqueloculina assemblage in the upper part of the *Elphidium angulatum* Zone (sample 32); almost monospecific assemblage composed mainly by *Cycloforina*.

Anomalinoides dividens assemblage in the *Anomalinoides dividens* Zone (samples 33 – 35); almost monospecific assemblage composed mainly by *Anomalinoides dividens*.

The benthic foraminiferal successions in the studied interval suggest normal marine salinity, inner shelf depth basin, with relatively small oxygenation and productivity changes during the late Badenian, the *Hanzawaia crassiseptata* chron. The rapid change in the taxonomic composition between the *H. crassiseptata* and *E. angulatum* zones reflected by extinction/disappearance of stenohaline taxa from the foraminiferal assemblages and replace them by euryhaline forms resulted from shallowing and decrease in salinity of the Polish Carpathian Foredeep Basin. The Badenian-Sarmatian boundary is located at the level of great faunal turnover, e.g. at the upper boundary of the *Hanzawaia crassiseptata* Zone (Peryt et al., 2021).

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References:

Harzhauser, M. & Piller, W. E., 2007: Benchmark data of a changing sea – palaeogeography, palaeobiogeography and events in the Central Paratethys during the Miocene. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 253, 8 – 31.

Pawłowska, K. & Kubica, B., 1960: Karta otworu wiertniczego Babczyn-2 (in Polish; unpublished). Archiwum CUG, Warszawa.

Peryt, D., Garecka, M. & Peryt, T. M., 2021: Foraminiferal and calcareous nannoplankton biostratigraphy of the Upper Badenian-Lower Sarmatian strata in the SE Polish Carpathian Foredeep. *Geol. Quart.,* 65, 18, 1 – 22.

Śliwiński, M., Bąbel, M., Nejbert, K., Olszewska-Nejbert, D., Gąsiewicz, A., Schreiber, B. C., Be-Nowitz, J. A. & Layer, P., 2012: Badenian-Sarmatian chronostratigraphy in the Polish Carpathian Foredeep. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 326 – 328, 12 – 29.

THE OTOLITH ASSEMBLAGE FROM THE VALANGINIAN, EARLY CRETACEOUS OF WĄWAŁ, POLAND

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We report rich Valanginian (Early Cretaceous) otolith-based ichthyofauna from Wąwał, central Poland. This assemblage displays considerable diversity of teleost teleost fishes immediately preceding The Great Fish Radiation. We identified 10 genera and species including one new otolith-based genus and species. The comparison to taxa from similar Cretaceous assemblages shows similarity to the Aptian (late Early Cretaceous) and less distinctly to Maastrichtian (latest Cretaceous) assemblages, rather than to its coeval equivalents. The vertical changes in otolith species composition in the succession at Wąwał follows similar pattern already revealed from the succession of bivalves and other benthic invertebrates attributed to the sea level and sea temperature variations observed in the area. The new findings suggest that The Great Fish Radiation, started well before the Aptian, and it was longer and more gradual process than previously thought. This fossil association also reveals significant shift in the abundance ratio of fish otoliths vs. cephalopod statoliths in fully marine deposits, with otoliths much more abundant than the statoliths in the Cretaceous, while reverse is true for the Jurassic. The research is supported by the NCN grant number: 2019/35/N/ST10/04160

References:

Cavin, L., 2008: Palaeobiogeography of Cretaceous bony fishes (Actinistia, Dipnoi and Actinopterygii). *Geol. Soc., London, Spec. Publ.,* 295, 1, 165–183.

Kaim, A., 2002: Gradual evolution of the Early Cretaceous marine gastropod Rissoina lineage in central Poland. Acta palaeont. pol., 47, 4, 667–672.

Reháková, D. & Michalík, J., 1997: Evolution and distribution of calpionellids – the most characteristic constituents of Lower Cretaceous Tethyan microplankton. *Cretaceous Res.,* 18, 493–504.

Kutek, J. & Marcinowski, R., 1996: Faunal changes in the Valanginian of Poland: tectonic or eustatic control. *Mitt. Geol.-paläont. Inst. Univ. Hamburg,* 77, 83–88.

Schwarzhans, W., 2018: A review of Jurassic and Early Cretaceous otoliths and the development of early morphological diversity in otoliths. *Neu. Jb. Geol. Paläont., Abh.*, 75–121.

INITIAL RESULTS OF THE UNIFICATION OF LOWER PERMIAN STRATIGRAPHIC SCHEMES OF THE INTRA-SUDETIC BASIN ACROSS THE POLAND – CZECH REPUBLIC BOUNDARY

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The lower Permian deposits of Intra-Sudetic Basin are divided by the state boundary into the southern-Czech and northern-Polish part leading to development of two different lithostratigraphic schemes for one basin. These deposits are arranged into two depositional sequences divided by regional unconformity that corresponds to the so-called Saale tectonic event. The lower complex (lower Rotliegend) is represented by the Chvaleč and Broumov formations in Czech part, and Krajanów and Słupiec formations in Polish part respectively. It comprises dominantly fine-grained, alluvial to lacustrine siliciclastic deposits, accompanied by volcanic rocks. The upper complex (upper Rotliegend) is represented by the Trutnov and Radków formations respectively. It is characterized by dominantly coarse-grained fluvial deposits of only poorly known age, because of the absence of fossiliferous horizons or volcanic intercalations. These schemes require standardization and unification, what constitutes one of the main objectives of a comprehensive transnational (Polish, Czech, German) investigation of the Permian of Intra-Sudetic Basin. Crucial task is the identification of stratigraphically equivalent units, while maintaining local diversity. Currently, diachronic lithosomes and lithostratigraphic names used in the Czech and Polish parts are not based on the same lithostratotypes, but depend on local profiles of the best exposed strata in both areas. To identify stratigraphically equivalent units, the results of facies analysis, together with the cluster of floristic and faunistic data were used. In our study, we try to create a uniform collection of fossils with regional correlation importance for the entire region. We used these groups which inhabited the semi-arid environment. These are mainly: footprints of Permian reptiles and amphibians, also very useful for more precise reconstruction of the Permian terrestrial ecosystems, skeletal fossils of aquatic vertebrates: chondrichthyans, actinopterygians and amphibians, also used to estimate their migration and biostratigraphic zonation, and plant remains. Also, volcanic rocks of the Intrasudetic Basin were used for geochronolgical study using zircon age dating, supporting stratigraphic correlations.

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CALPIONELLIDS AND CALCAREOUS NANNOFOSSILS – IMPORTANT TOOLS OF THE BIOSTRATIGRAPHIC CORRELATION OF UPPER JURASSIC-LOWER CRETACEOUS SEDIMENTARY SEQUENCES

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Thermal subsidence of individual, often interconnected basins created by gradual break-up of Pangea, as well as eustatic and climate variations affecting the chemistry and the trophic state of ocean water were major factors – which influenced the character of sedimentation during Late Jurassic and Early Cretaceousof Tethyan regions (Baumgartner, 2013). Rich planktonic assemblages developed in these basins, slopes, intrashelf elevations and partially also in the distal parts of carbonate ramps, which were characterized by a permanent current regime positively influencing the nutrient input. Radiolarians, *Bositra* shells (filaments), saccocomids, globochaetes, calpionellids, calcareous and non-calcareous dinoflagellates and nannofossils were dominated of planktonic assemblages at that time.

Calpionellids, probably ancient loricate planktonic ciliate protozoans, exibiting generaly the same morphological aspects and assemblages what supposed that their successive rapidly changing events are favourable for interregional correlations and they play the key role in biostratigraphy of Upper Jurassic/Lower Cretaceous sequences not only in areas lacking in ammonites. These events, allowed to create widely accepted calpionellid zonal scheme (Remane et al., 1986) later tested and accepted along whole Tethyan Realm (existed and used zonations are sumarized in Lakova & Petrova, 2013; López-Martínez et al., 2015) which counted seven calpionellid interval zones (Chitinoidella, Praetintinnopsella, Crassicollaria, Calpionella, Calpionellopsis, Calpionellites and Tintinnopsella) and 12 – 15 subzones which were defined in regional levels but majority of them comfirmed also interregional relevancy. Detail comparative analysis of calpionellid associations along the Tethyan areas show variations in relative abundance of species, species variability, changes in association diversity and also variability in the structural composition of their loricas.

As the oligotrophic organisms they were very sensitive to the environmental perturbation such the change of water temperature, chemistry, salinity and the nutrient supply. The abundance and size of calpionellidloricae were influenced by water temperature andthe sea-level fluctuations. Size of loricae decreased towards the open sea. They were less frequent in deep basins dominated by radiolarians, being very rare in reefal and lagoonal settings or in proximal settings with permanent river-influenced elevated nutrient level and with changes in surface water chemistry (Reháková, 2019).

The most actual studies (Wimbledon et al., 2020a, b; Casellato & Erba, 2021) concerning the revision of previously published data (Casellato, 2010) on distribution of nannofossils show closer relationship between the calpionellid and nannofossil events which seems to us were probably resulted from the position of these microplanktonic groups in their trophic level – producers versus consumers. Revised nannofossil zonation of the Tithonian –early Berriasian interval counts with NJT 14 Zone (NJT 14a and NJT 14b subzones), NJT 15 Zone (NJT 15a and NJT 15b subzones), NJT 16 Zone (NJT 16a and NJT 16b subzones), NJT 17 Zone, NC 0 Zone (NC 0a and NC 0b subzones) and NC 1 Zone. Casellato, Erba (2021) distinguished also several highly reliable and reliable nannofossil events and evaluated them against magnetostratigraphy and calpionellid zones. On the base of these new results it seems that the onset of so called "nannoconid word" of – Tremolada et al. (2006) coincide with the onset of hyaline calpionellids in the Praetintinnopsella Zone. Later, highly reliable events represented by the FOs of *Nannoconus wintereri*, *N. steinmannii minor* and *N. kamptneri minor* were identified close to the onset of Alpina event (Kowal-Kasprzyk & Reháková, 2019) in the Alpina Subzone of Calpionella Zone, what is very good argument for acceptation of all these events as supporting markers for J/K boundary limit. Last highly reliable events represented by the FOs of *N. st. steinmannii* and *N. k. kamptneri* seems to have closer relationship with overlying Ferasini and Elliptica subzones of the Calpionella Zone.

References:

Casellato, C. E., 2010: Calcareous nannofossil biostratigraphy of Upper Callovian-Lower Berriasian successions from the Southern Alps, N Italy. *Riv. Ital. Paleont. Strat.,* 116, 3, 357 – 404.

Casellato, C. E. & Erba, E., 2021: Reliability of calcareous nannofossil events in the Tithonian – early Berriasian time interval: Implications for a revised high resolution zonation. *Cretaceous Res.,* 117, 104611. doi.org/10.1016/j.cretres.2020.104611.

Baumgartner, P., 2013: Mesozoic radiolarites – accumulation as a function of sea surface fertility on Tethyan margins and in ocean basins. *Sedimentology,* 60, 292 – 318.

Kowal-Kasprzyk, J. & Reháková, D., 2019: A morphometric analysis of loricae of the genus Calpionella and its significance for the Jurassic/Cretaceous boundary interpretation. *Newslett. Stratigr.,* 52, 33 – 54. https://doi.org/10.1127/nos/2018/0461.

Lakova, I. & Petrova, S., 2013: Towards a standard Tithonian to Valanginian calpionellid zonation of the Tethyan Realm. *Acta geol. pol.,* 63, 2, 201 – 221.

López-Martínez, R., Barragán, R. & Reháková, D., 2015: Calpionellid biostratigraphy across the Jurassic/Cretaceous boundary in San José de Iturbide, Nuevo León, north eastern Mexico. *Geol. Quart.*, 59, 581 – 592.

Remane, J., Borza, K., Nagy, I., Bakalova-Ivanova, D., Knauer, J., Pop, G. & Tardi-Filácz, E., 1986: Agreement on the subdivision of the standard calpionellid zones defined at the IInd Planktonic Conference Roma 1970. *Acta geol. hung.,* 29, 5 – 14.

Reháková, D., 2019: Plankton evolution and biostratigraphy during Late Jurassic and Early Cretaceous. *Geol. Carpath., 70*, 137 – 140.

Tremolada, F., Bornemann, A., Bralower, T. J., Koeberl, C. & van de Schootbrugge, B., 2006: Paleoceanographic changes across the Jurassic/Cretaceous boundary: the phytoplankton response. *Earth Planet. Sci. Lett.,* 241, 361 – 371.

Wimbledon, W. A. P., Reháková, D., Svobodová, A., Schnabl, P., Pruner, P., Elbra, T., Šifnerová, K., Kdýr, Š., Frau, C., Schnyder, J. & Galbrun, B., 2020a: Fixing a J/K boundary: a comparative account of key Tithonian-Berriasian profiles in the departments of Drôme and Hautes-Alpes, France. *Geol. Carpath.*, 71, 1, 24 – 46.

Wimbledon, W. A. P., Reháková, D., Svobodová, A., Elbra, T., Schnabl, P., Pruner, P., Šifnerová, K., Kdýr, Š., Frau, C., Schnyder, J., Galbrun, B., Vaňková, L., Dzyuba, O., Copestake, P., Hunt, Ch., Riccardi, A., Poulton, T. P., Bulot, L. & De Lena, L., 2020b: The proposal of a GSSP for the Berriasian Stage (Cretaceous System): Part 2. *Vol. Jurass*., 18, 2, 119 – 158. ISSN (print) 1731-3708.

PALYNOFACIES AND NON-CALCAREOUS DINOFLAGELLATES AT THE CRETACEOUS/PALEOGENE BOUNDARY: BUKOVEC SECTION

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Within the GAČR 19-07516S project, several localities representing sedimentation around the Cretaceous/Paleogene boundary were studied. One of the localities is located east of the village Bukovec (southeast of Jablunkov). The locality consists of a zone of natural outcrops in the bottom and banks of the Oleška stream in the border zone of the Czech Republic and Poland.

The locality belongs to the Silesian Unit, Godula Development (prevailing turbidite fan facies, palaeodepth below the CCD; Picha et al., 2006). Litostratigraphically it belongs to Istebna Formation including contact with underlying and overlying strata (Godula Fm, Rožnov Fm) – stratotype section of Istebna formation under consideration. Lithologically, sandstones and conglomerates prevailing in the lower part; higher typical turbidites, with several claystone-dominated intervals and one conglomerate/sandstone body.

In the analysis, the organic matter found in the samples was classified into the following categories: black phytoclasts (divided into equidimensional and elongated), brown phytoclasts, cuticles, spores and pollen grains, algae, foraminifera and amorphous organic matter (AOM; Tyson, 1995). During this distribution, a large number of black phytoclasts were mostly found in the samples, which significantly exceeded the 50 % ratio of found organic facies.

The ratio of continental and marine organic particles is very much in favor of continental ones, which means significant resedimentation from the shelf.

The ratio of phytoclasts with respect to individual samples is very diverse, but in larger amounts black particles occur in the samples, which indicates the presence of oxygen during sedimentation. We can also observe a trend of increasing proportion of translucent particles from maastrichtian to palaeogene. This fact suggests a decrease in the presence of oxygen during sedimentation and possibly the formation of an anoxic environment.

In black phytoclasts, we distinguished two equidimensional shapes, ie small isometric and elongated. The ratio of these two types of black phytoclasts in the examined samples is significantly in favor of equidimensional ones. From these findings, we can call this sedimentary environment rather distal.

Assemblages in many samples of Maastrichtian are rich in species such as *Achomosphaera triangulata*, *Cerodinium diebelii*, *C. speciosum*, *Cleistosphaeridium cassospinum*, *Heterosphaeridium* sp., *Cordosphaeridium fibrospinatum*, *Glaphyrocysta castelanensis*, *Isabelidinium cooksoniae*, *Palaeocystodinium golzowense*, *Palaeohystrichophora infusorioides*, *Palaeoperidinium pyrophorum*, *Spiniferites septatus*, *Stephodinium* sp., *Subtilisphaera cassospinum* and *Systematophora* sp.

Assemblages with *Areoligera volata*, *Achomosphaera alcicornu*, *Achomosphaera triangulata*, *Cleistosphaeridium insolitum*, *Deflandrea* sp., *Florentinia* sp., *Glaphyrocysta* sp., *Homotryblium abreviatum*, *Hystricho-sphaeridium tubiferum*, *Hystrichokolpoma bulbosum*, *Kiokansium polypes*, *Operculodinium* sp., *Palaeocystodinium* sp., *Senoniasphaera inornata*, *Spinidinium densispinatum* and *Spiniferites pseudofurcatus* are typical for the Palaeocene.

References:

Picha, F. J., Stranik, Z. & Krejčí, O., 2006: Geology and Hydrocarbons Resources of the Outer Carpathians and their foreland, Czech Republic. In: Golonka, J. & Picha, F. J. (eds): The Carpathians and their foreland: Geology and hydrocarbon resources. *Amer. Assoc. Petrol. Geol., Mem.,* 84, 49 – 175.

Tyson, R.V., 1995: Sedimentary Organic Matter. Organic Facies and Palynofacies. *Chapman & Hall*, 615 p.

PALYNOFACIES AND NON-CALCAREOUS DINOFLAGELLATES AT THE JURASSIC/CRETACEOUS BOUNDARY: BRUZOVICE AND ROPICE SECTIONS

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The natural outcrops near Bruzovice and Ropice villages represent deep marine sediments of the Jurassic/Cretaceous boundary. Lower part of the section is formed by the uppermost part of the Vendryně Formation, which is represented by dark grey calcareous claystones with two horizons of concretions and blocks of limestones. Limestones represent gravels, blocks and concretions of size at least 1.5 m in size. Accumulation of limestones can be compared with the Ropice horizon (Menčík et al., 1983) which occures in the uppernost part of the Vendryně Formation. Upper part of profile is represented by lowest layers of Těšín Limestone, formed by light gray limestones (detritic in the lower part), gray, spotted claystones and marlstones.

Claystones of the Vendryně Formation provided a relatively poor association of non-calcareous dinoflagellates with *Circulodinium distinctum*, *Cometodinium* sp., *Cribroperidinium* sp., *Endoscrinium* sp., *Gonyaulacysta* sp., *Stiphrosphaeridium anthophorum*, *Systematophora areolata*, *Tubotuberela* sp., *Valensiella* sp. Dinoflagellate cyst association is of late Tithonian age. Palynofacies are dominated by phytoclasts and amorphous organic matter typical for anoxic environment.

Several useful biostratigraphic indicators are present near the base of the Těšín Limestone with the calpionellids of the Calpionella alpina Subzone. These indicators include *Amphorula delicata*, *Diacanthum hollisteri*, *Gochteodinia villosa*, *Hystrichosphaerina orbifera* and *Senoniasphaera jurassica*.

Stratigraphically important dinoflagellates were encountered in the higher part of Těšín Limestones: *Cometodiniu whitei*, *Cribroperidinium edwardsii*, *Dichadogonyaulax bensonii*, *Hystrichodinium voigtii*, *Muderongia longicorna*, *M. tabulata*, *Spiniferites* cf. *ramosus*, *Tubotuberella apatela*, and *Warrenia californica*.

Key FOs and Los of non-calcareous dinoflagellate cyst for the late Tithonian to early Berriasian were observed. The FO of *Glossodinium dimorphum* and *Amphorula metaelliptica*, and LO of *Prolixosphaeridium* *anasillum* occurred in the dinocyst Cadosian semiradiata Zone; the FO of *Diacanthum hollisteri* occurred in the calpionellid Calpionella alpina Subzone; the FO of *Dichadogonyaulax bensonii*, *Muderongia longicorna*, *M. tabulata* and *Spiniferites* cf. *ramosus* occurred in the calpionellid Remaniella ferasini Subzone; and the FO of *Achomosphaera neptunii* occurred in the lower part of the Calpionella elliptica Subzone.

Integrated micropaleontology of the sections is a part of multidisciplinary research including magnetostratigraphy, stable-isotope study and geochemistry of the JK boundary in frame of the project GAČR 20-10035S.

UNRAWELLING OF THE CRETACEOUS / PALEOGENE BOUNDARY EVENTS IN THE WESTERN CARPATHIANS: A STATE OF THE ART

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K/Pg boundary has been previously constrained in Western Carpathians, but its existence is still uncertain due to Laramian erosion and absence of lowermost P-serie biozones. New evidences of the K/T boundary has been gathered from the study of drill core sections in Horná Nitra Depression and Middle Váh Valley area.

K/Pg transition is most properly marked in the Kršteňany KRS-3 section, and that by the LO of *Abathomphalus mayaroensis*. Post-K/Pg recovery is recorded by appearance of microperforate species *Globoconusa daubjergensis*, *Eoglobigerina simplicissima* and *Parvularugoglobigerina eugubina* (P0 – Pα Zone). The section grades upward to the Selandian formation with praemuricid species and latter radiation of morozovellids, igorinids and fasciculiths. Thanetian formation is dated by *Globanomalina pseudomenardii*. The PETM interval is marked by excursion taxa (*Acarenina sibaiyensis*, *Discoaster araneus*) in magnetic reversal Chron C24r, followed by Ypresian formations with rich and diversified hispid morozovellid species (*M. formosa*, *M. subbotinae*, *M. aragonensis*, *M. lensiformis*, etc.), and higher up in Lutetian formations by association of *Morozovella gorrondatxensis*, *Turborotalia frontosa*, *Globigerinatheka kugleri*, *Acarinina topilensis*, *Morozovelloides* cf. *coronatus*, etc.

The Žilina-Hradisko section (Fig. 1) exhibits a continuous K/Pg boundary sequence, passing through the light gray Maastrichtian marlstones with rich globotruncanid and heterohelicid microfauna, across the dark grey bioturbated marls of lowermost Paleocene formation with disaster species like *Guembelitria* and *Globoconusa*. Beside of abrupt biotic changes, the K/Pg boundary is marked by elevated Hg concentrations. Planktic foraminiferal microfauna is enriched during late Danian by species of parasubbotinids, eoglobigerinids and praemuricids. The Lower Selandian microfauna is rich by morozovellid foraminifers like *M. angulata*, *M. acuta* and *M. conicotruncana* (P3b Zone). Globanomalinid foraminifers belong to species *G. ehrenbergeri* (P3 Zone) and its descendant species *Globanomalina pseudomenardi* (P4 Zone). Since the disappearance of *pseuodomenardii*, younger species of globanomalinids like *G. chapmani* and *G. australiformis* appeared during the Late Thanetian. Morozovellid foraminifers occurs as large-sized discoidal and biconvex species belonging to *Morozovella velascoensis* Zone (P5). Paleocene/Eocene boundary in the Žilina-Hradisko section is approximated by species *Morozovella marginodentata* and *M. gracilis*, which firstly appeared in the P5 Zone and terminated to the E1 - E3 Zones (Ypresian).

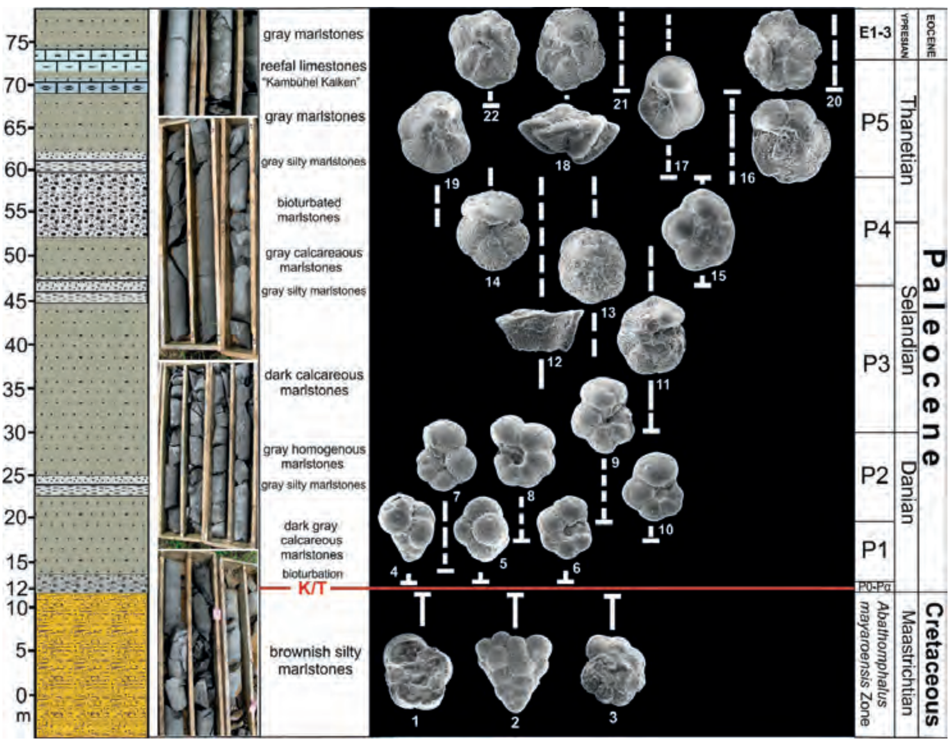

Fig. 1. Lithology and biostratigraphy of the Žilina core section. Vertical distribution of marker species of planktonic foraminiferal zones and stratigraphic stage boundaries. Numbers of indicated species: 1 – *Abathomphalus mayaroensis*; 2 – *Racemiguembelina fructicosa*; 3 – *Rugoglobigerina pennyi*; 4 – *Guembelitria cretacea*; 5 – *Globoconusa daubjergensis*; 6 – *Parvularugoglobigerina eugubina*; 7 – *Parasubbotina pseudobulloides*; 8 – *Praemurica inconstans*; 9 – *Praemurica uncinata*; 10 – *Globanomalina compressa*; 11 – *Morozovella angulata*; 12 – *Morozovella conicotruncana*; 13 – *Igorina albeari*, 14 – *Morozovella apanthesma*; 15 – *Globanomalina pseudomenardii*; 16 – *Morozovella velascoensis*; 17 – *Morozovella subbotinae*; 18 – *Morozovella occlusa*; 19 – *Morozovella acuta*; 20 – *Morozovella marginodentata*; 21 – *Morozovella gracilis*; 22 – *Planorotalites pseudoscitula.*

ANOXIA AS A FACTOR INFLUENCING OF MORPHOGENESIS OF PLANKTONIC FORAMINIFERA: EXAMPLES FROM THE EOCENE AND OLIGOCENE FORMATIONS OF THE WESTERN CARPATHIANS

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Planktonic foraminifers respond to oxygenation in the basinal water column. The expansion of the oxygen-deplected zone leads to changes in their functional morphology and to the development of unusual test morphologies. Such were the clavate and digitate forms of planktonic foraminifers in the Eocene and Oligocene anoxic formations.

Hantkeninids are digital foraminifers with chambers elongated into long tubulospinose projections. They represent the ecological adaptation of planktonic foraminifers escaping from the oxygen minimum zone for nutrients above the chemocline zone. They occur in the Middle Eocene formations of the central Western Carpathians, where they indicate a climate cooling after The Paleocene – early Eocene hyperthermal periods (PETM, EECO). They evolved from ancestral forms of the genus *Clavigerinella*, which descendants were subbotinids belonging to cool-water and eutrophic planktonic foraminifers. Hantkeninids and clavigerinids occur mainly in the Eocene formations in the Rajec, Turiec and Liptov basins. They are represented by species like *Clavigerinella eocenica*, *C. caucasica*, *Hantkenina mexicana*, *H. liebusi* and *H. dumblei*.

Homologous forms with digitate morphologies also occur in the Oligocene formations of the Western Carpathians in sulfidic-rich sediments of the Menilite formation. These clavate and stellate foraminifers belong to the species such as *Protentella rohiensis*, *Quiltyella clavacella*, *Q. nazcaensis*, *Beella digitata* and *Bolliella adamsi* (cf. Spezzaferri et al., 2018; Schiebel & Hemleben, 2017). The Carpathian findings of these species came from the Lower Oligocene formations revealing a conditions of Paratethyan isolation and stagnant anoxic regime of the basins. They were also described from the Transylvanian Basin (Popescu & Brotea, 1989), the Ždánice Unit (Švábenická et al., 2007) and the Fore-Alpine molasse basins (Rögl, 1969).

Beside of the digitate species, the anoxic conditions of the Oligocene formations are also indicated by the development of forms with secondary apertures on the spiral side of the tests. They belong to the genus *Globigerinoides*, which initial species of *G. primordius* appeared in the Late Oligocene having a spinose type of test walls like the genus *Globoturborotalita* but with one supplementary aperture. Thus, a basal species of a polyphyletic lineage leading to Neogene species of the genus *Trilobatus* also appeared in dysoxic conditions of the Oligocene basins (Spezzaferri et al., 2015).

Paratethyan conditions of semi-isolated basins are also indicated by endemic nannofossils (mainly *Reticulofenestra ornata* in the NP23 zone) and geochemical proxies of anoxic/suboxic environments.

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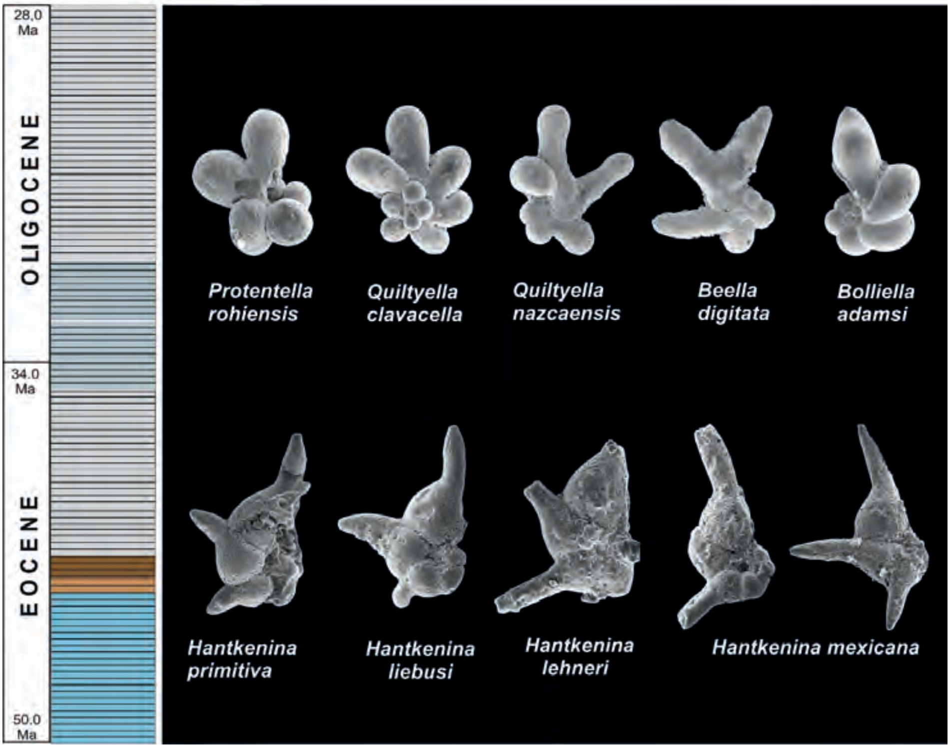

Fig. 1. Stratigraphic distribution and species diversity of the digitate planktonic foraminifera in the Eocene-Oligocene formations of the Western Carpathians.

References:

Popescu, G. & Brotea, D., 1989: Genus Protentella (Foraminifera) in North Transylvania Oligocene. The Oligocene from the Transylvanian Basin. *Cluj-Napoca,* 255–260.

Rögl, F., 1969: Die Miozäne Foraminiferenfauna von Laa an der Thaya in der Molassezone von Niederösterreich. *Mitt. Geol. Gessell. (Wien),* 61, 63–123.

Schiebel, R. & Hemleben, C., 2017: Planktic foraminifers in the Modern ocean. *Berlin-Heidelberg, Springer-Verlag,* 351 pp.

Spezzaferri, S., Kucera, M., Pearson, P. N., Wade, B. S., Rappo, S., Poole, R. Ch., Morard, R. & Stalder, C., 2015: Fossil and genetic evidence of the polyphyletic nature of the planktonic foraminifera *"Globigerinoides"*, and description of the new genus *Trilobatus*. PLOS ONE, DOI: 10.1371/journal.pone.0128108.

Spezzaferri, S., Coxall, H. K., Olsson, R. K. & Hemleben, Ch., 2018: Taxonomy, biostratigraphy, and phylogeny of Oligocene *Globigerina*, *Globigerinella*, and *Quiltyella* n. gen. *In: Atlas of Oligocene Planktonic foraminifera,* 179–214.

Švábenická, L., Bubík, M. & Stránik, Z., 2007: Biostratigraphy and paleoenvironmental changes on the transition from Menilite to Krosno lithofacies (Western Carpathians, Czech Republic). *Geol. Carpath.,* 58, 3, 237–262.

FIRST EVIDENCE OF ARTICULATED SHELL AND CALCIFIED BYSSI OF *ANOMIA EPHIPPIUM LINNAEUS* (BIVALVIA) FROM THE MIDDLE MIOCENE OF THE NOWY SĄCZ BASIN

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The Nowy Sącz Basin is a small intramountain basin situated in the Polish Outer Carpathians (c. 50 km to the south of the Carpathian overthrust upon the Miocene strata of the Carpathian Foredeep Basin). Its middle Miocene succession consists of both freshwater (Biegonice Fm) and marine deposits (Iwkowa and Niskowa Fms.); detailed stratigraphy and facies description has been provided by Oszczypko-Clowes et al. (2009).

The Badenian Niskowa Fm (sandy-silty marine deposits) approximately 60 m thick, covered by Pleistocene and Holocene shows a patchy appearance and only two localities have yielded diverse molluscan fauna: Niskowa near Nowy Sącz and the site situated along the left bank of the river Kamienica Nawojowska at the south-east outskirts of Nowy Sącz. The first fossil-bearing site has attracted the attention of researchers for almost 150 years (Bałuk, 1975), whereas the second was exposed during flooding in 2001. This new outcrop that occurs mainly in homogenous, poorly consolidated silty mudstones, greenish and dark grey in colour provided numerous bivalve species dominated by *Anadara diluvii* (Lamarck, 1805), *Anadara turonica* (Dujardin, 1837) and *Linga collumbella* (Lamarck, 1818). A unique feature of the bivalve fauna is the presence of seven articulated shells of *Anomia ephippium* Linnaeus, 1758, with a length of 28 mm to 72 mm. The most amazing fact, however, is the presence of the heavily mineralized byssus, which anchored the animal to hard substrates, preserved still inside the byssal notch (Studencka, 2018). This shallow-water species that presently inhabits the Atlantic coast (from Iceland to Ghana), the Mediterranean Sea and the Black Sea belongs to the family Anomiidae characterized by unique mode of attachment.

Bivalves which have adapted to life on rigid substrates, rocks and other shells, attach to them either by cementing parts of one valve, or by means of special anchoring protein lines, called byssus threads, secreted by the byssal gland in the foot. Whereas, like other members of the family Anomiidae, only juveniles of *Anomia ephippium* are temporarily attached by fine protein byssal threads passing from the inside of the left (upper) valve through the irregular pear-shaped notch in the right (lower) valve. Later, during ontogeny, the byssus gradually modifies to become a highly complex hierarchical structure. It consists of a lamellar aragonite part that forms the interface with the musculature of the animal, and a porous calcite part closer to the substrate (calcareous contents accounts for 90 % of the weight of the bysuss). A detailed description of the development of the byssal structure in the modern species *Anomia chinensis* Philippi, 1848 has been provided by Yamaguchi (1998). As the anomiid shell is thin and delicate, the calcified base of the byssus which is still attached to other shells is the only reference of the once living animal (Mejier, 1977). In some cases, however, the only evidence is *Centrichnus eccentricus* Bromley et Martinell, 1991, resulting from its etching activity. This ichnospecies known from the Late Cretaceous corresponds to the conspicuous imprint of the byssus and a shallow groove around the margins of the right valve (Neuman et al., 2015).

Apart from seven articulated shells and 90 left valves, collected material contains remains of some dozen of heavily mineralized byssi attached to other specimens of *Anomia ephippium* and to heavily fragmented valves of *Anadara diluviii* or *Anadara turonica* (Studencka, 2018). The study of the fossil *Anomia ephippium* has revealed that the structure of its calcified byssus is similar to those of modern *Anomia chinensis.* All studied fossil byssi represent the fifth stage of Yamaguchi (1998). Furthermore, the presence of the byssus with twisted aragonitic lamellae implies also that adult individuals of *Anomia ephippium* might have applied the same type of mobility as *Anomia chinensis*.

It should be emphasized that reports on presence of both right valves and articulated shells of *Anomia ephippium* are extremely scarce. They have been noted from the Pliocene and Pleistocene of the Mediterranean (Spain, France, northern Italy and Rhodes), although the species has been known since the Early Oligocene and during the Neogene it was widespread in all European provinces. In the Central Paratethys this widely distributed species has been hitherto represented exclusively by isolated left valves. The discovery of articulated shells in the middle Miocene (Badenian) at the Kamienica Nawojowska site is therefore the first in the Central Paratethys and the oldest among those described so far.

References:

Bałuk, W., 1970: The Lower Tortonian at Niskowa near Nowy Sącz, Polish Carpathians. *Acta geol. pol.,* 20, 101 – 157.

Mejier, T., 1977: De verkalkte byssus van Anomia. *De Kreukel*, 6, 4, 42 – 43.
Neumann, C., Wisshak, M., Aberhan, M., Girod, P., Rösner, T. & Bromley, R. G., 2015: *Centrichnus eccentricus* revisited: A new view on anomiid bivalve bioerosion. *Acta palaeont. pol.,* 60, 539 – 549.
Oszczypko-Clowes, M., Oszczypko, N. & Wójcik, A., 2009: New data on the late Badenian–Sarmatian deposits of the Nowy Sącz Basin (Magura Nappe, Polish Outer Carpathians) and their palaeogeographical implications. *Geol. Quart.,* 53, 273 – 292.
Studencka, B., 2018: A new look at the bivalve *Anomia ephippium* Linnaeus, 1758 from the Miocene of the Central Paratethys: an example from the Nowy Sącz Basin in Poland. *Acta geol. pol.,* 68, 635 – 650.
Yamaguchi, K., 1998: Cementation vs mobility: development of a cemented byssus and flexible mobility in *Anomia chinensis*. *Mar. Biol.,* 132, 651 – 661.

NEW FINDINGS OF PERMIAN POTENTIONAL FAUNA FROM THE PETROVA HORA FORMATION (JAKLOVCE, SLOVAKIA)

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During the geological mapping, an isolated accumulation, more than 20 m thick and 10 m wide, of densely accumulated lenticular bodies has been found (Fig. 1). The single occurrence is located 1 000 m northeast Kurtavá skala Quarry (791 m a.s.l.), northwest of the Jaklovce village (48°53’48.2”N 20°58’18.4”E). Studied area belongs to the Petrova hora Formation in Northern Gemericum (Vozárová & Vozár, 1988).

The studied rock samples are represented by slightly tectonically affected volcaniclastic sediments (tuffs) of mainly gray-violet, light green and beige colors with common disc-shaped bodies. They are preferably arranged in the direction of stratification (or in the direction of the deformation surfaces). The bodies have a lenticular shape on the profile (height 3 – 4 mm) and slightly elongate shape on the outline (length 5 – 20 mm). Unspecified rare “shell” fragments, considered by authors as bivalves or brachiopods are showing signs of lamination. Rounded elevations referring to the basal projection of the oldest part of the valve of the adult animal also occur. On the surface of these bodies, mainly non-carbonate (confirmed by electron probe microanalyzer/electron microprobe), zonally arranged layer can be observed macroscopically.

The morphological features are very poorly preserved and due to tectonic deformation, it is hard to determine the original shape of the valves.

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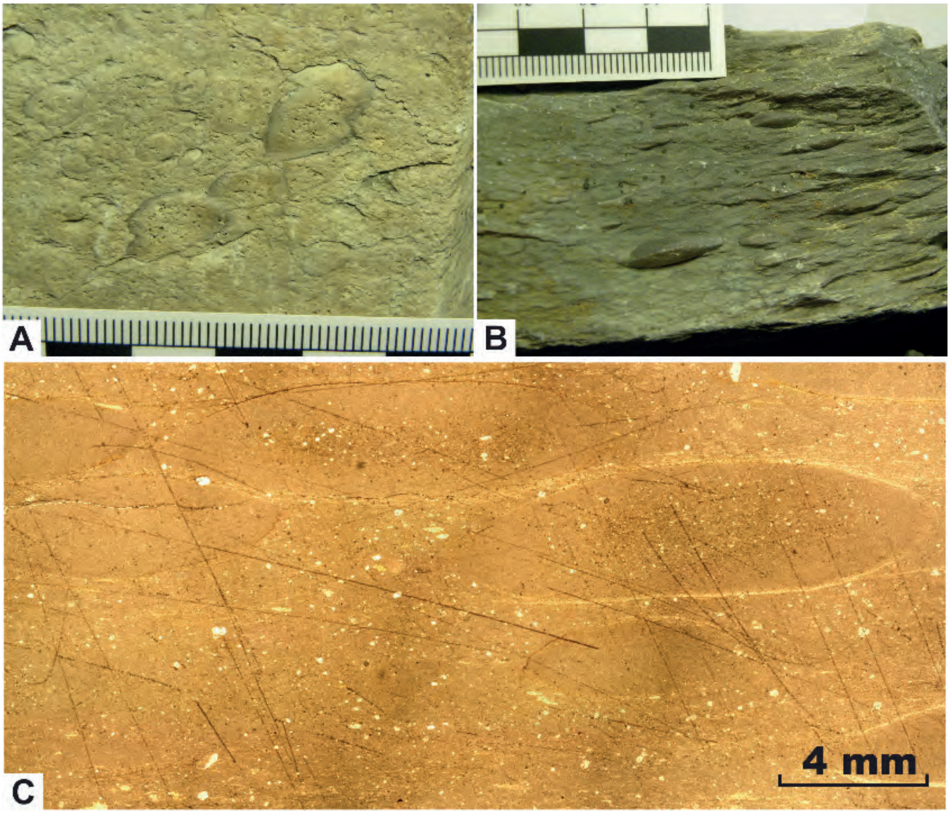

Fig.1. A – B – Lenticular shape bodies (macroscopic photo), B – Lenticular shape bodies in thin-section.

References:

Vozárová, A. & Vozár, J., 1988: Late Paleozoic in West Carpathians. *Bratislava, D. Štúr Inst. Geol.*, 1–314.

GASTROCHAENOLITES ICHNOFACIES FROM THE KINBERK LOCALITY: AN INSIGHT INTO ENDOLITHIC BIVALVE COMMUNITY OF MIDDLE TO LATE BADENIAN

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The discovery of the link between trace fossils and their tracemaker is generally a difficult task. However, in some cases, the tracemaker can be preserved inside the trace fossil or in close proximity. New finds from the well-known Badenian locality Kinberk (Czech Republic) sheds new light on tracemakers of *Gastrochaenolites* borings of the Vienna basin deposits.

The ichnogenus *Gastrochaenolites* is a relatively common trace fossil caused by endolithic bivalves. Boring bivalves usually occur in a dynamic environment with strong wave action and therefore their preservation potential is decreased. Bivalve borings were frequently reported from the deposits of the Vienna Basin (Pek and Mikuláš, 1999) as well as Carpathian Foredeep (Janoška et al., 1995; Mikuláš and Pek, 1995; Pek and Mikuláš, 1996; Pek et al., 1998). On the other hand, no body fossils of tracemakers were described. Only recently Šamánek et al. (2018) described assemblage with *Rocellaria* cf. *dubia*, *Gastrochaena* cf. *intermedia*, and *Hiatella arctica* from Borač-Podolí.

The studied assemblage comes from the uppermost layer of Badenian sediments cropping out of the vineyard section of the Kinberk locality. The Badenian sediments are covered by Quaternary loess. The layer is composed of rounded cobbles of various sizes with admixture of gravel and sand. The cobbles are frequently bioeroded. Bivalve borings predominate represented by several ichnospecies (*Gastrochaenolites lapidicus*, *Gastrochaenolites torpedo*, and *Gastrochaenolites orbicularis*) but borings of clionid sponges (ichnogenus *Entobia*) occur as well. The tracemakers of *Gastrochaenolites* borings are occasionally preserved in situ inside the borings. Studied trace fossils represent a typical example of *Gastrochaenolites* ichnofacies. Endolithic boring bivalves are represented by *Aspidopholas* sp. (cf. *rugosa* (Brocchi, 1814), *Jouannetia* (*Jouannetia*) *semicaudata* Des Moulins, 1828 and *Hiatella* cf. *rugosa* (Linnaeus, 1767). Infaunal non-boring bivalves are represented by *Tellina* (*Arcopagia*) cf. *crassa* Pennant, 1777, and *Lutraria* sp. that got into the borings secondarily. The Kinberk assemblage of endolithic bivalves did not share similarities with the assemblage from Borač-Podolí. The Borač-Podolí assemblage represents a sublittoral community utilizing colonial corals as a primary source of the substrate. Conversely, the Kinberk assemblage exemplifies a littoral community living in a high-energy environment and utilizing cobbles as a primary source of the substrate.

References:

Janoška, M., Mikuláš, R. & Pek, I., 1995: Stopy vrtavých badenských organismů na vápencových rockgroundech z Černotína (severní Morava). *Čas. Slezského zem. muz.,* 44, 2, 97 – 99.

Mikuláš, R. & Pek, I., 1995: Tertiary borings in Devonian limestone rockgrounds from Hranice (northern Moravia, Czech Republic). *Věst. Čes. geol. úst.,* 70, 1, 19 – 26.

Pek, I. & Mikuláš, R., 1996: Traces of boring activity of organisms on marlite cobbles at Česká Třebová (Miocene, lower Badenian, Czech Republic). *Věst. Čes. geol. úst.,* 71, 3, 285 – 290.

Pek, I. & Mikuláš, R., 1999: Stopy vrtavé činnosti organizmů badenského stáří od Mikulova. *Zem. Plyn Nafta,* 43, 4, 599 – 623.

Pek, I., Zapletal, J. & Janoška, M., 1998: Stopy vrtavé činnosti organismů na spodnobadenských valounech od Čelechovic na Hané. *Zem. Plyn Nafta*, 43, 1, 153 – 161.

Šamánek, J., Mikuláš, R., Doláková, N. & Hladilová, Š., 2018: Vrtby ichnorodu Gastrochaenolites jakožto životní prostředí mlžů z lokality Borač-Podolí (Karpatská předhlubeň, Česká republika). *Geol. výzk. na Moravě a ve Slezsku* 25, 1 – 2, 32 – 40.

BATHYMETRIC VARIATION IN THE COMPOSITION AND PRESERVATION OF FORAMINIFERAL ASSEMBLAGES DURING THE BAJOCIAN – BATHONIAN IN THE PIENINY KLIPPEN BELT

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The Middle Jurassic sediments in the Czorsztyn Unit of the Pieniny Klippen Belt record a bathymetric gradient spanning from coral bioherms (Vrsatec Formation), through crinoidal banks (Smolegowa and Krupianka formations) and sponge-stromatactis mounds with brachiopods (Bohunice Formation), up to nodular limestones (Czorsztyn Formation). This gradient covaries not only with declining light penetration but also with declining net sedimentation rate, decreasing substrate consistency, and declining contribution of benthic carbonate producers to carbonate sediments. Although lithologic and microfacies variation (with abundance of filaments in the uppermost Bajocian and Bathonian) along these gradients is well-documented on the basis of thin sections, crinoidal and nodular facies consist of highly time-averaged assemblages that represent relict or palimpsest deposits affected by reworking and complex burial/exhumation cycles (including phases of dissolution/cementation). These preservation pathways led to environmental and stratigraphic condensation that obscured initial depositional conditions and benthic community structure. In addition, the structure of benthic fauna inhabiting sponge habitats (leading in some cases to the preservation of stromatactis fabric) habitats remains enigmatic. To disentangle the effects of taphonomic and ecologic factors on bathymetric variation in the composition of benthic fossil assemblages, we analyzed variation in composition and preservation of foraminiferal assemblages at multiple sections of the Czorsztyn Unit. Analyses of thin sections show that the bathymetric gradient is characterized by a decline in abundance of encrusting foraminifers (*Nubecularia*) from 20 % (relative to all benthic foraminifers per thin section) in coral and stromatactis facies to 5–10 % in crinoidal facies and < 1 % in nodular facies. In contrast, abundance of *Lenticulina* peaks in crinoidal facies (> 40 %), is intermediate in stromatactis and nodular facies, and is very low in coral assemblages (< 5 %). Assemblages in crinoidal limestones show the highest compositional variation (overlapping with other facies types), indicating that benthic assemblages in crinoidal facies show the highest degree of between-habitat (spatial and temporal) mixing.

FOSSIL FLORA FROM THE HORNÁ VES LOCALITY, VTÁČNIK MTS.

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New occurrences of Fossil Flora were discovered in two small outcrops 85 m apart, near by Horná Ves village in the Vtáčnik Mountains. Lithostratigraphically the locality is situated in Vtáčnik Formation, represented by the pyroclastic currents deposits conected with autochtonously attacked pyroclastics, mostly tuffs and agglomerates (lower outcrop) and redeposited pyroclastics (upper outcrop) of early to middle Sarmatian, equally at both localities. The Fossil flora were documented by presence well preserved *Taxodium dubium, Glyptostrobus europaeus,* Monocotyledonae gen. et sp. indet., *Laurophyllum* sp., *Daphnogene polymorpha*, *Quercus mediterranea*, *Quercus kubinyii*, *Engelhardia orsbergensis*, *Carya* sp., *Myrica lignitum*, *Saporta*, Rosaceae. The occurrence of that Fossil Plant Community is unique according to the origin and clearly indicates the well-diversified Evergreen Broad Leaved Forest in subtropical climatic conditions.

Key words: Fossil Flora, Vtáčnik Fm, Sarmatian, subtropical climate, Horná Ves, Vtáčnik Mts.

PALEONTOLOGY AND PALEOECOLOGY OF SCAPHOPODS IN THE MORAVIAN PART OF THE CARPATHIAN FOREDEEP

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The class Scaphopoda is a poorly documented and often neglected class of molluscs. Their shells are in the shape of a slightly "curved tusk", which tapers towards the apex. Both ends of the shell are open. This is a cosmopolitan group of animals, limited to the marine environment, usually not tolerating decrease in salinity and living from tidal zones to a depth of 6 000 m (Lamprell and Healy, 1998; Jovanović and Bošnjak, 2016). In certain areas, this class is rare. It is a secondary component of fauna and occurs mostly only in a small number of individuals and species (Baluk, 1972).

New research of mollusc fauna in the southern part of the Carpathian Foredeep in Moravia focusing predominantly on Lower Badenian sediments in the Boskovice Furrow brought a large number of Scaphopoda individuals, which together with other molluscs and other groups of animals enable to interpret certain components of the palaeoenvironment.

In six main localities (Knínice-Kovářovice 2, Knínice-South, Šebetov-Čtvrtě, Sebranice 2, Šlapanice and Borač) in total over 500 individuals of scaphopods were found, from which eight species were determined. The individuals found are very often well preserved, in some cases with broken apex. In some shells predation traces of the species *Oichnus* sp. were obserwed.

The found scaphopods, mainly from the area of Boskovice Furrow, can be divided into 2 basic groups. The first one consists of shallow-water associations with the dominant species *Gadila ventricosa*, and abundant gastropod *Turritella badensis* and coral *Tarbelastrea reussiana*. To a lesser extent, even the species *Fustiaria jani* and *Fustiaria emersoni* also occur in these localities. This association was found in sandy clay with frequent fragments of sandy or algal limestones (Sebranice 2), which also formed massive layers in the bottom (Knínice-Kovářovice 2). The interpreted sedimentation depth for this group was probably up to 50 m. The second group consists of deep-water species with the dominant *Entalina* *tetragona*. This species occurs together with the gastropods *Turritella spirata*, *Ancillaria pusilla* and *Euspira helicina* and bivalves *Corbula gibba*. This association of molluscs forms the dominant component of the fauna in most localities, often exceeding 90 % of the individuals found. At the Šebetov-Čtvrtě locality, even the scaphopods *Dentalium mutabile* and gastropods *Nassarius striatulus* occure in this association. This deep-water association was found mostly in calcareous clays and the sedimentation depth for this group could exceed 100 m.

References:

Baluk, W., 1972: Lower Tortonian scaphopods from the Korytnica clays, southern slopes of the Holy Cross Mts. *Acta Geol. pol.,* 22, 3, 545 – 571.

Jovanovič, G. & Bošnjak, M., 2016: Fissidentalium badense (PARTSCH in HÖRNES, 1856) from the Badenian deposits of the south and southwestern margin of the Pannonian Basin System (Central Paratethys). *Geol. Croat.,* 69, 2, 195 – 200.

Lamprell, K. L. & Healy, J. M., 1998: A revision of the Scaphopoda from Australian waters (Mollusca). *Rec. Australian Mus.,* Suppl. 24, 1 – 189.

RHYNIOPHYTOID PLANT FROM THE UPPER SILURIAN POŽÁRY FORMATION (PRAGUE BASIN, CZECH REPUBLIC) – A POSSIBLE INTERMEDIATE BETWEEN BRYOPHYTES AND VASCULAR PLANTS?

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Land plants include bryophytes (comprising liverworts, hornworts, and mosses) and the clade Polysporangiophyta (*sensu* Kenrick & Crane, 1997), which includes all vascular plants. Although the evolutionary relationship between bryophytes and vascular plants remains unclear, the model of monophyletic evolution of bryophytes or hornworts as a sister group to the rest of the land plants is widely supported (Morris et al., 2018). In the early beginnings of the terrestrialization process, the oldest land plants, like recent bryophytes, were probably dependent on aquatic environments or moist substrates. It is therefore assumed that organization of these plants was at the bryophyte-like grade (Wellman & Gray, 2000).

An interesting plant megafossil exhibiting both polysporangiate and bryophyte-like characters was briefly reported by Kraft et al. (2019). The rhyniophytoid plant was described as ?*Fusiformitheca* sp. and is housed at the West Bohemian Museum (labeled as WBM F21762). This study provides a detailed morphological description of the plant. The specimen comes from the tuffaceous shales of the Požáry Formation of the Kosov Quarry near Beroun, which is part of the Prague Basin, the Barrandian area. The specimen represents three times dichotomously branched plant, which is at least 18 mm high. The plant exhibits narrow naked axes with dichotomous branching and terminal sporangia. A significant feature of this plant is the vertically elongated sporangium with narrowing to a very sharp tip.

Based on the branched sporophyte, the plant is classified within the clade Polysporangiophyta. However, the markedly vertically elongated sporangium exhibits several bryophyte-like features including: a) it is capsule-shaped, b) an outer layer forming a sheath enveloping inner more recalcitrant tissue, c) an internal elongated structure situated at the base of the sporangium resembling a column of sterile tissue, and d) sporangial apex conspicuously devoid of organic matter (possibly a tip of the sheath).

It is now premature only based on morphology to determine whether this plant could indeed be a representative combining features of vascular and bryophyte-like plants. As this is the only specimen from the Barrandian area, more representatives of this taxon are needed to be found for further study.

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References:

Kenrick, P. & Crane, P. R., 1997: The Origin and Early Diversification of Land Plants: A Cladistic Study. *Washington, DC, Smithsonian Inst. Press,* 441 pp.

Kraft, P., Pšenička, J., Sakala, J. & Frýda, J., 2019: Initial plant diversification and dispersal event in upper Silurian of the Prague Basin. *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 514, 144 – 155.

Morris, J.,L., Puttick, M.,N., Clark, J. W., Edwards, D., Kenrick, P., Pressel, S., Wellman, C. H., Yang, Z., Schneider, H. & Donoghue, P. C., 2018: The timescale of early land plant evolution. *Proc. Naion. Acad. Sci.,* 115, 2 274 – 2 283.

Wellman, C. H. & Gray, J., 2000: The microfossil record of early land plants. *Philosoph. Trans. Royal Soc. London, Ser. B: Biol. Sci.,* 355, 717 – 732.

LOWER CRETACEOUS AMMONITE ASSOCIATIONS IN THE WESTERN CARPATHIANS (MORAVIAN-SILESIAN AREA AND WESTERN SLOVAKIA)

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The presented paper is devoted to the evolution of Lower Cretaceous ammonite associations in *neighbouring* tectonic units of the Western Carpathians and to their comparison with the current international ammonite zonation in Reboulet et al. (2018). In particular, the Silesian Unit in the western sector of the Outer (Flysch) Carpathians of the Moravian-Silesian region, some localities of the Pieniny Klippen Belt in Western Slovakia, and prominent localities in the Manín and Krížna nappes in the Central Western Carpathians are discussed. Data on the local ammonite spectrum in these units have been revised and updated in accordance with catalogues of the Lower Cretaceous ammonites (Klein, Klein and co-authors, starting in 2005) and other taxonomic papers published in this millennium.

The Lower Cretaceous ammonite-bearing sediments of the Outer Western Carpathians in the Silesian Unit of the Godula Development are characterised by a flyschoid development with a dominant pelitic component. In some sections with predominant calcareous to non-calcareous pelitic rocks, and in the upper Hauterivian substantially, layers with a predominance of graded sandstones occur. Claystones and marlstones are grey to dark-grey in colour, so that the general term of "Black Cretaceous" is sometimes used for this unit. Pelitic deposits are accompanied by horizons of lenticular pelosiderites (clay siderites).

Selected localities in the Pieniny Klippen Belt include the Podbranč quarry near Myjava, the Na Dlhej quarry near Horné Srnie, Rochovica near the municipality of Brodno, as well as Revišné and Podbiel near basins of the Orava River. These localities are characterised by a very complicated geological structure consisting of profiles with less complete sequences, which are not rich in continuous occurrence of ammonites. The substantial part of the layered sequence (the Valanginian to the Barremian) shows the marly limestone development.

The most complete Lower Cretaceous ammonite-bearing layered sequences (the Valanginian to the upper Barremian) are situated in the Central Western Carpathians, dominated by the Polomec quarry near

Lietavská Lúčka and, in particular, by the Butkov quarry near Ladce in the Považie Region. Pelagic marl and carbonate deposits are light in colour. Part of the sequence contains cherts and turbidite layers. Local sediments were and are still mined (in the second case) as cement raw material.

Distribution tables (Tables 1 – 2) show a selected number of those ammonite species that belong to present zonal species or to species that served as guide species in earlier years, or to other species of guiding character that have occurred at least in two of the tectonic units under study. Attention is also paid to the occurrence of the so-called boreal species. Characteristic species are presented in temporal succession from the Valanginian to the Aptian and they are correlated with international ammonite zones by Reboulet et al. (2018).

The Carpathian ammonite associations in the Valanginian and Hauterivian are close to the ammonite association in the Vocontian Basin belonging to the Mediterranean bioprovince. The studied Carpathian tectonic units were originally located at the margin of the Western European Platform, with the Silesian sedimentary area situated closest to the margin and the Central Carpathian sedimentary basins situated furthest away. The subsequent ammonite association of the Barremian and lower Aptian in the Silesian Unit of the Godula Development differs distinctly from the Mediterranean bioprovince compared to the other two units, in particular due to its different character of facies.

The basic palaeogeography in relation to occurrences of boreal ammonites in the Western Carpathians has been discussed by Vašíček and Michalík (2002). Rawson (1994) has stated that the change of faunas between the Boreal and Mediterranean regions occurred in three stages, via the Danish-Polish Depression. The first event took place in the lower Valanginian in the Pertransiens ammonite Zone and at the beginning of the Neocomiensiformis Zone. This event is associated with the occurrence of the genus *Platylenticeras*; however, its occurrence is known only in the Silesian Unit. The second event is associated with the upper Valanginian, with the Verrucosum and the lower Peregrinus Zones. This connection is evidenced in the Pieniny Klippen Belt by the occurrences of the genera *Valanginites*, or *Criohimantoceras*, and in the Central Carpathians by *Valanginites*, *Dichotomites* and *Neocomites* cf. *peregrinus*. The third penetration in the lower Hauterivian – the occurrence of the genus *Endemoceras* – has not been clearly documented in the Western Carpathians. Later, this connection ceased to exist.

After a longer period without boreal ammonites in the Western Carpathians, representatives of the genus *Procheloniceras* occur in the lower Aptian of the Silesian Unit. Mutterlose (1992) associates this boreal genus with a short migration in the strait between the Northern France and Southern England opened around the Barremian/Aptian boundary.

References:

Klein, J., 2005: Lower Cretaceous Ammonites I. Perisphinctaceae 1: Himalayitidae, Olcostephanidae, Holcodiscidae, Neocomitidae, Oosterelidae. In: Riegraf, W. (ed.): Fossilium Catalogus I: Animalia, pars 139. *Leiden, Backhuys Publ.,* pp. 186.

Mutterlose, J., 1992: Migration and evolution patterns of floras and faunas in marine Early Cretaceous sediments of NW Europe. *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 94, 261 – 182.

Rawson, P. F., 1994: Sea level changes and their influence on ammonite biogeography in the European Early Cretaceous. *Palaeopelagos, Spec. Publ.*, 1, 317 – 326.

Reboulet, S., Szives, O., Aguirre-Urreta, B., Barragan, R., Company, M., Frau, C., Kakabadze, M. V., Klein, J. et al., 2017: Report on the 6th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Vienna, Austria, 20th August 2017). *Cretaceous Res*., 91, 100 – 110.

Vašíček, Z. & Michalík, J., 2002: Boreal elements in the Lower Cretaceous ammonite associations of the West Carpathian Tethyan sector. In: Michalík, J. (ed.): Tethyan/Boreal Cretaceous Correlation. Mediterranean and Boreal palaeobiogeographic areas in Central and Eastern Europe. *Bratislava, Veda*, 115 – 136.

RE-INTERPRETATION OF *NOTOTHYLACITES FILIFORMIS* FROM THE LATE CRETACEOUS OF SOUTH BOHEMIA

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The type material of ***Notothylacites filiformis*** Němejc & Pacltová 1974 comes from the Klikov Formation (Turonian–Santonian) cropping out in the locality Zliv-Blana in the South Bohemian Basins. The material was published in 1974 by prof. F. Němejc and prof. B. Pacltová. The extraordinary well-preserved specimen shows very thin dichotomizing liverwort thalli which seemed to be bearing very short-stalked oval sporogons. After maceration, the sporangium showed multiple tetrads and individual spores which morphological structure corresponded to those of *Notothylas*. Because of an unusual combination of features, a new genus *Notothylacites* together with a new specimen *Notothylacites filiformis* Němejc & Pacltová were established. Although the features of sporangium and spores are hornworts-like and the genus *Notothylas* from which the name *Notothylacites* was derived is a part of Anthocerotophyta (hornworts), Němejc and Pacltová considered the species to be a liverwort.

This concept has been challenged by several studies on fossil bryophytes demonstrating a contradictory combination of features of both liverworts and hornworts, but none of them were treated in much detail. On top of that, the holotype of the specimen was thought to be lost for more than four decades but was recently re-discovered in the personal collection of prof. Pacltová which is now deposited in the National Museum, Prague.

After revision of the holotype and its comparison with recent hornworts, a new concept of the taxon is proposed. Because both hornworts and liverworts grow in humid environments in immediate proximity to each other, various taphonomic pathways may have caused an apparent connection of both plants during their fossilization. What now seems to be one plant, may be in fact fragments of two independent plants compressed in sediment to each other. Due to this fact and revision of the holotype, the authors propose the separation of a fertile part as *Notothylacites filiformis* (Němejc & Pacltová) (sporangium and spores) and sterile part – dichotomizing thalli as a new species of *Ricciopsis*.

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A NEW FIND OF CARBONIFEROUS LIMESTONE BOULDER NEAR KUČEROV (BADENIAN CLASTICS, CARPATHIAN FOREDEEP, CZECH REPUBLIC) – DISCUSSION OF PALEONTOLOGICAL, BIOSTRATIGRAPHIC, AND MICROFACIES DATA

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The Lower Badenian basal and marginal clastics of the Carpathian Foredeep considerably differs in composition with respect to provenance of the source material and are known under various local names. This contribution is focused on the Upper Tournaisian limestone boulder found in the field between Kučerov and Lysovice villages, ca 6.5 km south of Vyškov (Czech Republic). The boulder possesses typical whitish calcareous coating and derives from the so-called Lutršték gravels. These gravels have high content of the Culmian rocks and Devonian limestones, but contain also material derived from the Western Carpathians, metamorphic and igneous rocks (Šob, 1940). The boulder was studied for microfacies, foraminifers, brachiopods and trilobites, and its provenance was also discussed. Following major points might be highlighted:

1. Microfacies corresponds to floatstone with packstone/grainstone matrix. Allochems are dominated by crinoids, peloids and foraminifers. Intraclasts, cortoids, oncoids, solenoporacean and dasyclad (*Koninckopora* Koninck) algae, *Girvanella* Nicholson & Etheridge, ostracods, trilobites, brachiopods, bryozoans, parathuramminids, moravamminids, some other microproblematica and quartz grains were also recorded. Grains > 2 mm include some bioclasts, oncoids, and intraclasts.

2. Foraminifers indicate very narrow interval within the lower portion of the Upper Tournaisian MFZ8 Zone. This narrow interval is characterized by the co-occurrence of *Darjella monilis* Malakhova and *Eoparastafella* ex. gr. *vdovenkoae*.
3. Brachiopod fauna shows moderate diversity, with 14 brachiopod species recognized. Association includes abundant chonetidines [*Megachonetes zimmermanni* (Paeckelmann) and other rugosochonetids] which are associated with less frequent strophomenides (*Leptagonia* M'Coy) and orthotetides (Pulsiidae, Schuchertellidae). The spire-bearers (spiriferides, ? athyrides), orthides and productidines are rare.
4. Trilobites are represented by several specimens of the genus *Cummingella* Reed. Although the determination at the specific/subspecific level is complicated mainly by the insufficiently preserved cephalic parts, it is obvious that the new material is not identical with the species previously recorded in the Czech Republic. Based on the preserved characters, there are some similarities with subspecies of *Cummingella belisama* Hahn, Hahn & Brauckmann, *Cummingella jaroszi jaroszi* Osmólska and subspecies of *Cummingella carringtonensis* (Etheridge) (see Hahn & Hahn, 2008 for summary of *Cummingella* species).

These findings demonstrate that part of dark grey limestone clasts from the lower Badenian clastics originates from Carboniferous strata and not from Devonian strata, as supposed by the previous authors. Microfacies and foraminifers closely resemble those known from the coeval calciturbidites in the Mokrá Quarry near Brno (Ondráčková, 2001; Kalvoda et al., 2010). The boulder thus probably originates from the vicinity of Mokrá or from the limestone olistholits in the Drahany Upland Culm. The origin in the presumed Badenian elevations from the south (so-called "Těšín-Slavkov ridge") seems to be unlikely since there is no record of the corresponding stratigraphic level from this area.

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References:

Hahn, G. & Hahn, R., 2008: Catalogus trilobitorum cum figuris (Trilobites Carbonici et Permici, VI. Cummingellinae). Fossilium Catalogus I: Animalia. *Backhuys Publishers, Margraf Publishers*,145, 1–433.

Kalvoda, J., Devuyst, F.-X., Bábek, O., Dvorák, L., Rak, S. & Rez, J., 2010: High-resolution biostratigraphy of the Tournaisian-Visean (Carboniferous boundary interval, Mokrá quarry, Czech Republic). *Geobios,* 43, 317–331.

Ondráčková, L., 2001: Systematika rodů *Eoparastafella* a *Eoendothyranopsis* a popis mikrofacií při hranici tournai/visé na profilech v Mokré u Brna. *Rigorózní práce* (advanced master´s thesis, manuscript). Přírodověd. fakulta Masaryk. Univ., Kat. geol. paleont., Brno, Czech Republic.

PRAGIAN/EMSIAN STAGE BOUNDARY: SEARCHING FOR A NEW BASAL EMSIAN GSSP IN THE PRAGUE SYNFORM

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The current basal Emsian GSSP was defined in the Zinzil'ban Gorge in the Kitab State Geological Reserve, Uzbekistan based on FAD of conodont *Polygnathus kitabicus* Yolkin, Weddige, Izokh & Erina. (Yolkin et al., 1997). Further research revealed, that this GSSP is considerably older than the base of the classical Emsian in German sense and fall in lower half of the original Pragian (Carls et al., 2008). Attempts to find a new appropriate level for GSSP redefinition on the Zinzil'ban Gorge section did not yield promising results. In 2019, the Subcommission on Devonian Stratigraphy decided to look for new appropriate section for the redefined base Emsian GSSP, the most promising candidates are situated in the Spanish Central Pyrenees and in the Prague Synform. Lower Devonian successions in the Prague Synform were extensively studied for conodont biostratigraphy as well as palaeontological, sedimentological, geochemical and petrophysical record (e.g., Chlupáč et al., 1998; Bábek et al., 2018; Slavík & Hladil, 2020; Weinerová et al., 2020, and references therein).

Slavík & Hladil (2020) summarized the conodont data from the Early Devonian from the Prague Synfrom and provided the most recent conodont zonation in this area. These authors proposed the *gracilis* Event as the alternative marker approximately corresponding to the traditional boundary between Pragian and Emsian stages. Two conodont taxa with very similar first appearance, *Polygnathus excavatus excavatus* Carls & Gandl and *Latericriodus bilatericrescens gracilis* Bultynck, were discussed as potentially significant for the definition of new basal Emsian GSSP. These taxa enter close to the local Bohemian Graptolite Event.

The main task of the ongoing project supported by the Czech Science Foundation "Proposal for the GSSP of the basal Emsian boundary in the Prague Synform" is to complete robust data (biostratigraphy, sedimentology, faunal content, geochemistry and petro-physical data) for the proposal for a GSSP candidate section. The main attention is focused on several sections with Bohemian Graptolite Event or with its presumed equivalent (Pod Barrandovem section, Požár 3 Quarry, Mramorka Quarry, Branžovy Quarry).

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References:

Bábek, O., Faměra, M., Šimíček, D., Weinerová, H., Hladil, J. & Kalvoda, J., 2018: Sea-level changes vs. organic productivity as controls on Early and Middle Devonian bioevents: Facies- and gamma-ray based sequence-stratigraphic correlation of the Prague Basin, Czech Republic. *Global Planet. Change* 160, 75 – 95.

Carls, P., Slavík, L. & Valenzuela-Ríos, J. I., 2008: Comments on the GSSP for the basal Emsian stage boundary: the need for its redefitition. *Bull. Geosci.,* 83, 4, 383–390.

Chlupáč, I., Havlíček, V., Kříž, J., Kukal, Z. & Štorch, P., 1998: Palaeozoic of the Barrandian (Cambrian to Devonian). *Prague, Czech Geol. Surv.*, 183 pp.

Slavík, L. & Hladil, J., 2020: Early Devonian (Lochkovian – early Emsian) bioevents and conodont response in the Prague Synform (Czech Republic). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 549, 109 – 148.

Weinerová, H., Bábek, O., Slavík, L., Vonhof, H., Joachimski, M. M. & Hladil, J., 2020: Oxygen and carbon stable isotope records of the Lochkovian-Pragian boundary interval from the Prague Basin (Lower Devonian, Czech Republic). *Palaeogeogr. Palaeoclimatol. Palaeoecol.,* 560, 110 – 036.

Yolkin, E. A., Kim, A. I., House, M. R, Weddige K. & Talent, J. A., 1997: Definition of the Pragian/Emsian stage boundary. *Episodes*, 20, 4, 235 – 240.

THE NESTOR OF THE SLOVAK PALEONTOLOGY prof. RNDr. JOZEF ŠVAGROVSKÝ, DrSc. – CURRICULUM VITAE, CONTRIBUTION TO THE SCIENCE AND ITS COLLECTIONS IN THE SLOVAK NATIONAL MUSEUM – NATURAL HISTORY MUSEUM IN BRATISLAVA; CONTRIBUTION TO THE 100TH ANNIVERSARY OF THE BIRTH

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Professor J. Švagrovský was one of the most important personalities in the field of paleontology in Slovakia. In May 2021, is the 100th anniversary of the birth of prof. RNDr. Jozef Švagrovský, DrSc. He was born on the 2nd of May 1921 in Sečovce, eastern Slovakia. He obtained the basic education in his hometown, and passed the school leaving examination in the high school in Michalovce. During the years 1945–1948 he studied at the Faculty of Natural Sciences, Comenius University in Bratislava. In 1950 he completed his studies successfully with defending his dissertation and he passed a rigorous exam in the field of geology and paleontology. He was a student of Academic D. Andrusov.

Since 1949 he worked at the Institute of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava. He was mainly engaged in the research of molluscs from the Neogene formations of the Western Carpathians. He combined the acquired knowledge with the geological conditions of the localities and applied it in biostratigraphy and palaeoecological interpretation. In 1954 he habilitated as an Associate professor and in 1962 he obtained the title of University professor. During the years 1954–1956 he was the Vice-dean for pedagogical issues and in the years 1960–1962 as the Dean he led the Faculty of Natural Science, Comenius University in Bratislava. He was in charge of many important positions and he was a member of the editorial boards of different magazines. He obtained various honors for his work and contribution. Professor J. Švagrovský suddenly died on December 18, 1985 at the age of 64.

Professor J. Švagrovský has published the results of his scientific research in many scientific papers in domestic and foreign journals. It describes many species, which form the largest collection of palaeoevertebrates in the SNM-NHM today. He presented the results of his work at the paleontological seminars and conferences in Slovakia and abroad. He was the author of several textbooks and university scripts. Professor J. Švagrovský also promoted paleontology to the public, as evidenced by his popular-scientific contributions. He educated a number of students and researchers. He lectured paleontology to students of geology and biology and had a great contribution to the development of paleontological research in Slovakia.

The result of his active scientific work is a comprehensive collection, which can be found in the paleontological department of the SNM-NHM with a number of beautiful molluscs, as well as documentary originals from his scientific work. 12 4436 pieces of collection items from prof. J. Švagrovský under 9 394 registration numbers. His findings have been gradually registered since 1956 and they are registered under 31 incremental numbers. The materials were obtained by purchase, donation, and also by the transfer from the Department of Geology and Paleontology of the Faculty of Natural Sciences, Comenius University in Bratislava after his death. These are mostly molluscs (bivalves and gastropods) of Badenian and Sarmatian age, mostly from Slovak localities, especially from the eastern Slovakia, the Vienna Basin and the SE part of Moravia (Czech Republic). The collection is mainly from the Slovak localities (390 localities), to a smaller range from the Czech Republic (70 localities) and finally from Poland (6 localities). The most numerous locality, in terms of the number, of determined taxa is the Borský Mikuláš locality, vineyards of the Badenian age, where 110 taxa of bivalves and gastropods come from. Most specimens are registered from the locality Kalša, SW, brook and up to 10 254 pieces of gastropods. As for the registration numbers, most of them come from the locality Skároš, borehole F-10 of the Sarmatian age, namely 501 registration numbers (of which 11 registration numbers of bivalves and 490 registration numbers of gastropods). The collection contains a total of 1 007 taxa (of which 241 bivalves and 746 gastropods). The genus *Ervilia* is the most represented in the collection of bivalves (8 176 pieces) and the genus *Pirenella* is among the gastropods (28 321 pieces).

Professor J. Švagrovský contributed to science by describing several new species. Many of those type specimens are the main part of his collection, namely holotypes and paratypes of bivalves (5 species each), holotypes of gastropods (30 species) and paratypes of gastropods (27 species).

The significance of his entire collection is not only in the large number of registered taxa, but also the fact that some samples come from localities that no longer exist. It is also important that the samples will be preserved for the study of the future generations of paleontologists.

EARLY MIOCENE CALCAREOUS NANNOPLANKTON IN NORTHWESTERN PART OF THE TRENČIANSKA KOTLINA BASIN (WESTERN CARPATHIANS, SLOVAKIA)

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Calcareous nannoplankton was studied during the geological mapping of the Trenčianska kotlina Basin (Pešková et al., 2021). The basin is filled by the Eggenburgian transgressive sediments of the Čausa Formation. Studied Čausa Fm sediments consist of transgressive continental to neritic conglomerates and sandstones and pelagic grey-blue calcareous claystones. The best recorded sedimentary sequence of the area was documented by the PB-1 borehole (Gabčo et al., 1963). The sampling sites of pelagic claystones are marked as site 1 (Soblahov), site 2 (Trenčianska Turná-Hámre) and site 3 (Chocholná-Velčice). Studied sites yielded Early Miocene nannoplankton assemblage of NN2 Zone based on the occurrence of *Helicosphaera scissura* Miller, *Helicosphaera recta* (Haq) Jafar & Martini, *Helicosphaera ampliaperta* Bramlette & Wilcoxon (Perch-Nielsen), and *Helicosphaera carteri* (Wallich) Kamptner (Pelech et al., 2020). The younger sedimentary record is fragmentary and consist of the Pliocene gravels and Quaternary fluvial and eolian deposits. The Trenčianska kotlina Basin formerly represented an Early Miocene wedge top basin, connected with nearby Vienna Basin, Blatné depression, as well as the Bánovská kotlina, Hornonitrianska kotlina, and Ilavská kotlina basins. There are no strong arguments for interpretation of the pull-apart nature of the basins as it was considered in the past.

Key words: Central Paratethys, Early Miocene, Middle Váh Valley, Internal Western Carpathians, Calcareous Nannoplankton

References:

Gabčo, R., Seneš, J., Lehotayová, R. & Planderová, E., 1963: Zpráva o geologickom mapovaní na liste mapy 1 : 50 000 Považská Bystrica v roku 1962. Manuscript. Bratislava, archive SGIDŠ (arch. no. AP 4362), 14 p.

Pelech, O., Žecová, K., Jamrich, M., Littva, J., Demko, R., Zlinská, A. & Olšavský, M., 2020: Trenčianska kotlina and Ilavská kotlina basins – Remnants of an inverted Early Miocene wedge top basin (Western Carpathians, Slovakia). *Miner. Slov.,* 52, 1, 1–22.

Pešková, I., Teťák, F. (eds.), Pelech, O., Sentpetery, M., Olšavský, M., Kováčik, M., Maglay, J. & Vlačiky, M., 2021: Geological map of the Biele Karpaty Mts. (Northern part) 1 : 50,000. *Bratislava, St. Geol. Inst. D. Štúr*.

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