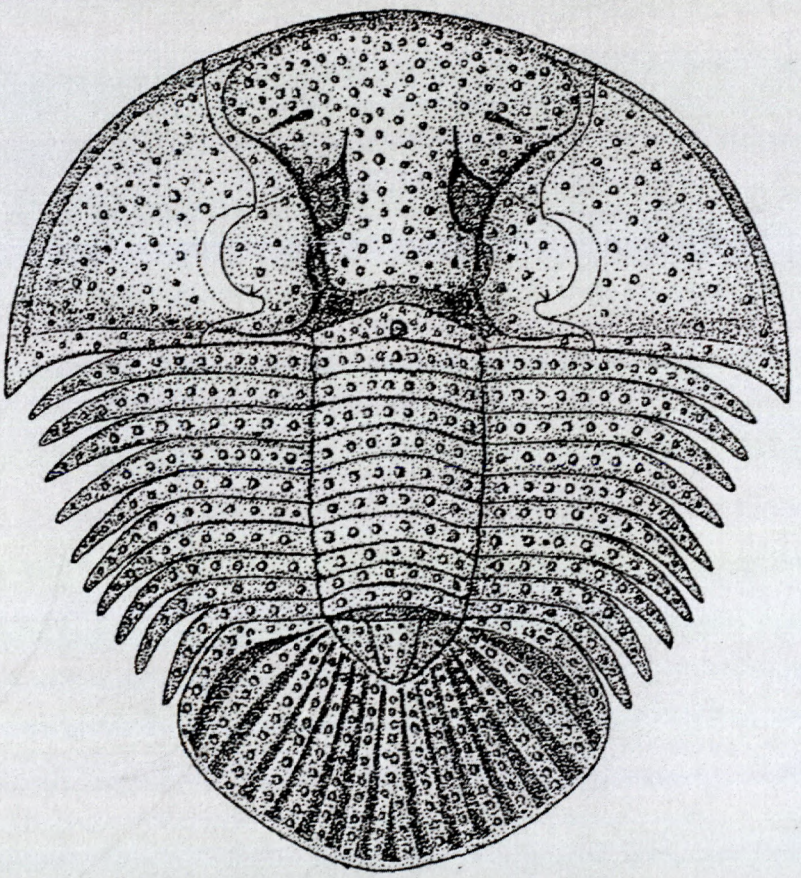
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PRAHA 2006

EDITORIAL

The present volume of the *Acta Universitatis Carolinae – Geologica* is the proceedings volume for the Second Czech and Slovak palaeontological meeting and contains papers which were delivered as oral presentations and/or posters in the meeting program. The volume contains the majority of papers presented at the meeting and serves to illustrate some of the current palaeontological research in the Czech and Slovak republics. Most of the papers were submitted with camera-ready illustrations. However, in several instances, this was not the case and we have redrawn illustrations.

The present special volume contains 25 contributions in the form of abstracts, extended abstracts and papers covering major part of topics of the current palaeontological research in the Czech and Slovak republics. All papers were reviewed by one or two referees. Only minor corrections and editorial changes were made to revised manuscripts and thus the authors are responsible for the contents and language of their contribution.

In the first part of the volume, several short papers summarize research activities of seven Czech and Slovak palaeontologists. These contributions were written to commemorate their importance for the development of palaeontology in the Czech and Slovak republics.

PROGRAM

Pondělí, 18. června 2001

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U příležitosti 70. narozenin prof. RNDr. **Oldřicha FEJFARA**, CSc.

9^{50} KALVODA JIŘÍ
Kulaté výročí prof. RNDr. Rudolfa Musila, DrSc.

10^{10} MAZUCH MARTIN
Kulaté výročí prof. RNDr. Oldřicha Fejfara, CSc.

10^{30} ZAJÍC JAROSLAV
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11^{15} MAZUCH MARTIN a KOŠŤÁK MARTIN
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11^{30} HOLEC PETER
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člena korespondenta ČSAV

14^{10} EDER-KOVAR JOHANNA
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Prof. RNDr. František Němejc, DrSc. – zakladatel české a slovenské moderní paleobotanické školy

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15^{25} VAVRDOVÁ MILADA
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Úterý, 19. června 2001

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Prof. Dr. FRANTIŠEK NĚMEJC, DrSc.,
corresponding member of the Czechoslovak Academy of Sciences, founder of the modern Czech and Slovak palaeobotanical school

ZLATKO KVAČEK

Charles University, Institute of Geology and Palaeontology, Albertov 6, 128 43 Praha 2, Czech Republic

Prof. Dr. Fr. Němejc (12. 6. 1901–7. 3. 1976) means in the development of palaeobotany in our country undoubtedly the same personality as Seward in Great Britain, Zeiller in France, Kräusel in Germany, Szafer in Poland, Kryshtofovich in Russia and Birbal Sahni in India. Němejc himself had many tutors and co-workers, who influenced his life career. Among his professors, three names must be quoted, the botanists Karel Domin and Karel Kavina and the geologist Cyril Purkyně. From among his colleagues, he co-operated first of all with Quaternary malacologist Jaroslav Petrbok, botanist František Arne Novák, professor at the Charles University, palaeobotanist Jaromír Šetlík, geologist Vsevolod Čechovič, and palaeobotanist/dendrologist Rudolph Florin (Stockholm).

Beginnings of Němejc's scientific career are connected with the National Museum in Prague, where he was recommended by Domin. Right at the beginning he showed his abilities in routine taxonomic and museum work, when he organised the type collection of Kaspar Sternberg, previously dispersed among other museum material. He also took part in extensive field works, particularly concentrated to the Bohemian Carboniferous, but also in the Balkan Peninsula. Besides, he devoted much time in collecting plant impressions in Quaternary travertine layers all over Central Europe. His joint adventures with Petrbok in Slovakia are well known.

Despite his handicap in feeble sight, he mastered all modern techniques in palaeobotanical research including the study of spores *in situ* (in the case of *Noeggerathia*), cuticles (*Frenelopsis*), algae in thin sections (Rhodophyta), and he was much interested in palaeoxylotomy as well. Unfortunately he did not find time for the latter kind of research during his whole lifetime. In spite of this, we can call Němejc one of the last polymaths in palaeobotany, who had profound knowledge over all spectrums in the field of plant megafossils. In the time of his activities in the National Museum he published also general contributions to the systems of angiosperm and evolution of higher plants in general.

During the Second World War, when Germany occupied our country, Němejc married young lady Olinka, who was his faithful wife watching his every step lifelong. We all know prof. Němejc without moustache, but he wore it before the marriage looking quite differently. In bad times of the occupation and also after the Second World War during the communistic regime, Němejc acted always as a kind, but at the same time firm, brave man of principle. He always found ways how to tackle with obstacles of political regimes. And our older generation knows well, how difficult were the living conditions and scientific activities at those times.

I met personally prof. Němejc during my university studies in 1950s and was fortunate to become his student. He changed his position at the museum for the university in 1952. As a university professor he formed the chair of palaeontology at the Charles University in Prague together with professor J. Augusta, associate professors Vl. Pokorný, Z. Špinar, B. Pacltová and assistant professors D. Jírová, J. Kukalová, J. Obrhel and J. Beneš. Already at that time he founded his own palaeobotanical school. He initiated the palynological research carried out later by prof. Pacltová, he supervised V. Sitár in Bratislava, who was his successor in Slovakia and, during several years, he educated in Prague a suite of young palaeobotanists including me. These were Miloš Procházka, Jiří Obrhel, Stanislav Hurník, Zdeněk Rieger, František Holý, Čestmír Bůžek and Erwin Knobloch to name the most important persons. His last postgraduate student was Antonín Hluštík, who studied the Cretaceous floras. In this period till his death Němejc wrote his textbook in palaeobotany. Its four volumes form in fact a compendium of knowledge in palaeobotany at that time. Despite the fact that only the version written in Czech language exists, the book has been used and is widespread in world libraries and institutions and among private palaeobotanists, who, not knowing a word of Czech, still make use of this survey according to the Latin names and figures. It is very sorry that this book was not translated into English, which was planned but never realised.

Prof. Němejc was appreciated worldwide as a prominent personality in palaeobotany. Many fossil plants were named in honour of him from various epochs. As examples the following taxa are to be quoted: genera *Nemejcopteris* Barthel, a coenopterid fern from the Upper Palaeozoic of Europe, *Nemejcia* Knobloch et Z. Kvaček, enigmatic verticillate plant remains from the Eocene sandstone of western Bohemia, microfossils *Nemejcosporites, Nemejcipollis*. We may name a long row of species with epithets *nemejcii,* e.g. *Laurophyllum nemejcii* Z. Kvaček from the Miocene – now *L. saxonicum* Litke, *Phyllites nemejcii* described by Bůžek from the Miocene of the Most Basin etc.

In this short contribution I have not intended to give a profound reappraisal of Prof. Němejc's life work. A number of jubilee articles were issued at various periods of his career and most important are quoted below (see references). Also the full bibliography was compiled by Pacltová (1971) and issued by the Czech Botanical Society. One article written by Holý (1995) and edited posthumously is particularly noteworthy because of excerptions from Němejc's diaries, which he kept notoriously till his last day. It is very pity, that the last entry from March 7th, 1976 remained unfinished. Prof. Němejc did not return from his regular afternoon walk as he used to having been killed by a car when crossing the street near his home. But we all, who knew him, will always remember his "krucaj-fucaj" when he was upset and his kind smile on his face in good moon.

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Narodí-li se někdo v Podkrkonoší a značnou část svého života věnuje Českému ráji, nelze se ani moc divit, že ho od počátku do konce jeho života poznamená zdejší kouzelná příroda. A nelze se ani moc divit, je-li tato poznamenávající příroda neživá.

To se právě stalo Josefu Soukupovi, jehož sté výročí narození připadlo letos na astronomický první jarní den. Ano, 20. března 1901 se před sto lety narodil v malebném podkrkonošském městečku, v Jilemnici. K poznávání přírody našel oporu malý Josef už doma. Jeho otec, jménem také Josef, vrchní veterinární rada, sbíral minerály i zkameněliny Podkrkonoší i Českého ráje a psal o nich i články do krajového sborníku „Od Ještěda k Troskám". Ale nejen je. Byl i znalcem místní květeny. Tak se doma potkal budoucí student jičínského gymnázia i s prvními křídovými zkamenělinami, které mu učarovaly mnohem více než barevné acháty a jaspisy. Na svého otce vždy s úctou vzpomínal a když jsme se později sblížili, často mi vykládal, jak otec nosíval domů zkameněliny a jak je spolu nad Fričovými pracemi probírali a určovali je.

Jičínské gymnázium mělo na Josefa Soukupa také svůj vliv. Byli to nejen výborní učitelé, profesoři Antonín Houba a Bruno Valoušek a nejen, co se týkalo studia přírodních věd. Zejména prof. Valoušek, který tíhnul ke geologickým vědám a který napsal pojednání o jičínských třetihorních sopkách a i o dalších geologických pozoruhodnostech Jičínska, hlavně o pískovcových útvarech Prachovských skal a později se stal učitelem i na Pedagogické fakultě UK v Praze, dal mladému Soukupovi solidní základ fyzické geografie. Také po stránce společenské však bylo studium gymnázia pro Soukupa důležité. Josef Soukup totiž na gymnáziu studoval v době, kdy mezi jeho spolužáky patřila i řada pozdějších osobností, které poznamenaly v dobrém českou kulturu. Patřili k nim například spisovatelé Knob a Knap, poznal zde rytce Havlase a seznámil se s budoucím malířem Kinským. Největší přátelství však uzavřel s Josefem Macháčkem. Spojovala je láska ke křídovým zkamenělinám i sedimentům, což oba v dalším životě mnohokrát prokázali. Proto jeho největší láskou zůstaly přírodní vědy a z nich pak geologie a paleontologie. Jim se rozhodne věnovat své budoucí studium na Karlově univerzitě v Praze. Studentem byl pilným, ale spíše než na studia, při nichž dosáhl úplné středoškolské aprobace z přírodopisu a zeměpisu, vzpomínal později na začátky své praxe v Národním muzeu i na své učitelské povolání, kterému se věnoval po roce 1930. Působil na několika středních školách a po dosažení doktorátu přírodních věd v roce 1934 i jako asistent Geologicko-paleontologického ústavu Karlovy univerzity.

To už se plně věnuje geologii a paleontologii. A své první práce z let 1928 až 1933 věnuje křídové paleontologii Jičínska. Křídová fauna z Konecchlumí, z Kamenice, z okolí Trosek, ale také z Chlomeckého hřbetu u Mladé Boleslavi a později i z Vyskeře a při srovnání i z dalších lokalit zaplňuje jeho život. Již tehdy byly bohaté jeho sběry zkamenělin z české křídy a některé jeho nálezy byly publikovány v paleontologickém díle H. Anderta (1934). Tehdy začala vlastně vznikat jeho sbírka, o které dodnes kolují i mnohé pověsti.

Ve své vědeckovýzkumné a sběratelské činnosti pokračoval Josef Soukup i v době, kdy se věnoval učitelskému povolání. V letech 1936–1938 učil na menšinových středních školách v Krasíkově a Štítech a v roce 1939 také krátce v Hořicích v Podkrkonoší. Tehdy publikoval několik závažných stratigraficko-paleontologických studií z české křídy Lanškrounska a Hořicka a opět se vrací k regionu Jičínska a Mladoboleslavska. Z té doby pochází také jeho práce o pseudokrasových jevech z kvádrových pískovců Českého ráje, publikovaná ve Sborníku OJKT v roce 1937. V roce 1939 odchází z učitelské služby jsa povolán do Státního, později Ústředního ústavu geologického v Praze, kde de facto působil až do svého skonu v roce 1980. Dalších přejmenování této instituce se tedy nedožil a myslím si, jak jsem ho znal, že by mu to bylo patřičně líto.

Jeho vědeckovýzkumná práce v ústavu byla velmi rozmanitá. Zasahuje do různých odvětví geologického výzkumu. Podílí se na geologickém mapování a stratigraficko-paleontologickém bádání, podílí se na ložiskovém výzkumu nerudních surovin, zejména cenomanských jílovců, na hydrogeologickém výzkumu sedimentů české křídy, na poradní službě, ale především se věnoval petrologickým, stratigrafickým a paleontologickým výzkumům sedimentů české křídové pánve. Stále se však vracel ke studiu geologie křídových sedimentů v širším okolí Jičína, ať již šlo o soupis lomů okresu Jičín z roku 1940, či poválečné práce z okolí Boháňky u Hořic, Mlázovic, Spojil i samotného Jičína.

Tady můžeme rozlišit v jeho výzkumu dvě, a z mého pohledu tři, etapy. V první etapě publikoval důležité detailní stratigraficko-paleontologické práce ze severočeské, východočeské i moravské části křídové pánve. Během těchto výzkumů získal řadu zkušeností a přehled o problémech týkajících se české křídy. To mu pak dovolilo ve druhé etapě uspokojivě řešit zejména některé palčivé stratigrafické otázky tohoto terénu tak, že jeho řešení byla přijímána jako platná pro celou oblast české křídové pánve. Jeho zkušenosti a rozhled se projevily zejména při edici přehledných geologických map měřítka 1 : 200 000, kde bylo třeba uspokojivě řešit otázky jednotné stratigrafie českých svrchnokřídových sedimentů. Nemenší pozornost si zaslouží, jak napsal ve Věstníku ÚÚG v článku k Soukupovým šedesátinám prof. Josef Dvořák, i jeho podíl při se-

stavování speciálních geologických map, jeho monografii o ložiskách cenomanských jílovců v Čechách a na Moravě (II. díl) a zejména jeho stratigrafické studie týkající se otázky hranice mezi turonem a senonem v české křídě a úpravu stratigrafického členění sedimentů české křídové pánve. Tyto zásadní práce vyšly v letech 1955 a 1956 a staly se na dlouhou dobu, prakticky, dalo by se říci symbolicky, až do roku jeho úmrtí, základním dílem, o nějž se opírala česká křídová stratigrafie. Dále přispěl k řešení závažné otázky hranice mezi středním a svrchním turonem v obtížném území saského Elbsandsteingebirge a Českého Švýcarska a k paralelizaci této oblasti se slínitou oblastí drážďanskou. Pracoval na četných heslech Naučného slovníku geologického ze šedesátých let a na geologických průvodcích českou křídovou pánví pro sjezdy Čs. společnosti pro mineralogii a geologii, i pro Mezinárodní geologický sjezd roku 1968, který se měl uskutečnit v Praze.

Nezapřel však své původní učitelské povolání. Značnou část svého, bezesporu vzácného, času věnoval sbírkám muzeí a škol, dopisoval si s řadou učitelů základních a středních škol, část svých sběrů věnovával muzeím i školním sbírkám a zůstával neustále ve spojení se svým kolegou ze studií, prof. Josefem Macháčkem, a pomáhal mu vydatně budovat kouzelné železnické muzeum. Určitou odměnou mu byly četné zprávy o výkopech v křídových sedimentech, o nálezech zkamenělin, o odkrytých nových profilech. Pokud mu dovoloval čas, navštěvoval je a dokumentoval. A to je třetí etapa jeho práce. V té jsem ho poznal, napřed jako student křídové paleontologie a geologie, kdy se ke mně choval s určitou rezervou, myslím, že oprávněně, protože o své tehdejší činnosti si nedělám vůbec žádné iluze, později jsme se však potkali v době, kdy jsem pracoval v Muzeu Českého ráje. Tehdejší ředitel muzea Jan Knob byl spolužákem Soukupovým z jičínského gymnázia a byl to on, který změnil vztah dr. Soukupa k mé osobě. Tehdy jsem začal dokumentovat stávající křídové profily ve sběrné oblasti muzea a dr. Soukup se mi stal učitelem a rádcem. Jakmile mu vybylo trochu času, přijížděl do Turnova a pak jsme konali dlouhé túry přírodou Českého ráje. A nebyly to jen geologické záležitosti. Od svého otce měl bohaté znalosti zejména o rostlinstvu Českého ráje, upozorňoval mne na řadu zajímavých míst, kde rostly vzácné druhy vstavačů, koniklece i přeslička obrovská. Hodiny jsme proseděli pod Hlavatou skálou pod Troskami a pozorovali sokolí pár, jak krmí mladé na tehdy posledním hnízdě sokola stěhovavého v Českém ráji. Tehdy také vznikl nápad, že chráněná krajinná oblast Český ráj by měla mít ve znaku Trosky a sokola. O mnoho let později se tento nápad uskutečnil. Svým způsobem i jako památka na Josefa Soukupa. Sbírky muzea utěšeně rostly a i jejich dnešní stav je z velké části Soukupovým dílem. Tehdy jsem měl také možnost poprvé, a nikoliv naposled, nahlédnout do jeho vlastní sbírky. To bylo v době, kdy jsem započal studovat křídovou faunu gastropodů. Spolupráce však neskončila mým odchodem z Muzea Českého ráje na Ochranu přírody do Prahy. Často jsem doprovázel dr. Soukupa po nalezištích kolínské oblasti i po dalších křídových lokalitách. Opět jsme hovořili o nutnosti jejich ochrany a nejen s ním. Byli i další vědečtí pracovníci, kteří to pokládali za nutné. Přípravu k jejich ochraně jsem započal, byli však další, kteří dotáhli tuto myšlenku do konce.

To už stál dr. Soukup mimo svou činnou službu a věnoval se zejména uspořádání a zpracování svých rozsáhlých sběrů. Pak přišla nemoc. Vážná nemoc, která mu prakticky zabránila dokončit rozsáhlé dílo věnované především geologii, stratigrafii a paleontologii české křídové pánve. Dr. Josef Soukup zemřel 14. března 1980.

Bývá zvykem, že na konci podobných proslovů bývá celkové hodnocení člověka. Rád bych se mu vyhnul, protože se domnívám, že nejlepším hodnocením života a díla dr. Josefa Soukupa jsou jeho život a jeho dílo samy. A pro nás, jeho pokračovatele, pak příklad jeho píle, neutuchající touhy po vědění a lásky k české přírodě a zemi.

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PROFESSOR MUSIL – 75

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On 5 May 2001 Professor Rudolf Musil, an outstanding Czech paleontologist and Quaternary geologist, celebrated an important life jubilee. He was born in Brno-Líšen, situated at the southern margin of the Moravian Karst, and this region has attracted his attention up to the present and affected his development. Already in the pre-war era he began to deal with amateur speleology, continuing that activity after finishing his studies at the classical grammar school in 1945, when he entered the Faculty of Science of Masaryk University, studying natural history and geography. There he had the honour of getting acquainted with a number of the then scientific experts who influenced his further scientific career. They were not only geologists and paleontologists Zapletal, Zahálka and Krejčí and geographers Vitásek and Krejčí, but also significant experts of biological sciences, such as Úlehla, Podpěra, Suk and Hrabě. He graduated from the Faculty of Science, Masaryk University in 1949 and then became a teacher at Petřvald near Ostrava.

After finishing his military service his further fate was for a long time connected with the Moravian Museum, where he worked from 1953 for more than 20 years as a research worker, head of the geological and paleontological division and the head of the museum. During his activity he participated considerably in the reorganisation of all collections of fossil vertebrates (more than 1 million specimens) and collections of evertebrates (about 300,000 specimens), the library and the overall modernisation of the geological and paleontological division.

Already during his military service Professor Musil presented and discussed his dissertation thesis called "Pleistocénní fauna dvou nových jeskyní" (Pleistocene fauna of two new caves) and his scientific career continued also during his activities in the Moravian Museum. In 1957 he submitted his candidate thesis "Die Mammutmolaren von Předmostí" which he discussed at Charles University in Prague in 1960. One of his evaluators was also Professor of Charles University and an outstanding Czech paleontologist Josef Augusta. Already since the beginning of his work in the Moravian Museum Rudolf Musil has acted as a pedagogue at the Faculties of Science and Arts of UJEP in Brno, being in charge of the most varied types of Quaternary geological and museological lectures. In 1960 he was appointed director of studies of postgraduate students in the branch of zoopaleontology, and in 1966 he habilitated for the branch of biology of the Quaternary and paleontology. The evaluators of his habilitation thesis: "Die Höhle Švédův stůl, ein typischer Höhlenhyänenhorst" were the then significant scientific experts, Professor Josef Augusta and Professor Josef Pelíšek. In 1967 Rudolf Musil became head of the board of examiners for the discussion of dissertation theses in paleontology at the Faculty of Science, UJEP in Brno. Another significant scientific act was the discussion of the doctor's dissertation thesis (DrSc.) at Charles University in Prague "Die Bärenhöhle Pod hradem. Die Entwicklung der Höhlenbären im Letzten Glazial." In connection with that, in 1970 he became a member of the committee for discussing doctor's dissertation theses (DrSc.) in the branch of paleontology.

Another part of Professor Musil's career was for more than 20 years immediately connected with the Department of Geology and Paleontology of the Faculty of Science in Brno, whose head he was in the years 1978–1989. In 1980 he became full professor of paleontology and during his activities at the faculty he held a number of functions in rigorous committees, committees for candidate dissertation theses and doctor's study programmes. He was head director of a number of dissertation theses and participated in the education of specialists, such as Šárka Hladilová or Martin Ivanov. He directs postgraduate students even today. He was at the formation of the interdisciplinary study of the Quaternary at the Faculty of Science, Masaryk University, and since 2000 he has been head of the branch council for those studies.

In 1991 Rudolf Musil retired, and had a partial contract. In 2000 he became Professor Emeritus of the Faculty of Science, Masaryk University. Pedagogical activities of Rudolf Musil continue, however, not only at the Faculty of Science, Masaryk University, but also at the Faculty of Science, Comenius University in Bratislava, and also within the lectures at the University of the 3rd Age at the Technical University in Brno.

The professional orientation of Rudolf Musil includes a very broad spectrum whose practical illustration is the attached bibliography. The main research activities were concentrated on fossile vertebrates (above all mammals and birds, Pleistocene as well as Pliocene), their systematics, interspecies changes and their utilisation for the stratigraphy as well as for the development of species and changes of assemblages in the course of the Pleistocene in relation to changes in the environment and the stratigraphy of the Pleistocene. Significant has been the co-operation of Professor Musil in long-term paleontological investigations of the Quaternary abroad, particularly in Germany. Up to the present they are projects Bilzingsleben and Schöningen. To the most significant belong his papers dealing with the studies of mammoths, cave bears, the phylogenesis of horses and the mongraph of Stránská skála rock. Further paleontological topics included general

problems of evolution and extinction, problems of biostratigraphy and paleoecology, as well as taphonomy and biostratonomy.

Research activities from the branch of Quaternary geology included speleology, the study of loesses and river terraces and their stratigraphy, the study of cave and fluvial sediments and fossil soils. Significant is the monograph Moravský kras (Moravian Karst). Besides, Professor Musil has dealt with problems of museology, protection of the environment, the history of geological sciences and the theory of management.

Professor Musil has been a member of a number of boards of editors, professional societies and scientific committees. Worth mentioning is above all the Society for Mineralogy and Geology, where in 1960–1980 he was a member of the committee and later the chairman of the branch group of paleontology and the chairman of the Brno branch, the advisory body of the Protected landscape region of the Moravian Karst, or the Czech stratigraphic commission. Up to now he is an elected member of the International Commission on the History of Geological Sciences.

For his professional activities Professor Musil has been awarded a number of appreciations, the most significant being the Silver Commemorative Medal for the merits in the development of the Moravian Museum in Brno, the Silver Medal of the National Museum in Prague, the Medal of Comenius University, the Golden Commemorative Medal of Masaryk University and the Commemorative Medal of J. Petrbok of the Czech Speleological Society.

Besides the varied professional activity Professor Musil has been characterised by a number of further interests. Since his young days he has been fascinated by the Scout Movement. This interest of him, like many other interests, survived up to his mature age, when he acted as a leader of the pack of Wolf Cubs. After the renewal of the Scout Movement he became a member and later the head of the Club of Old Scouts. His Scout past was continued by his interest in tourism and high mountain tourism, which survive up to the present. Since his youth he has been interested in sports, he is the holder of the Tyrš badge of fitness, besides an active interest in light athletics he played basketball and for a long time volleyball. Since 1985 he has been member of Slovácký krúžek (the Moravian Slovak circle) and with a nice song he likes sitting with a glass of good Moravian wine.

Even today Professor Musil has a very good physical condition and a great life energy. Besides regular research activities in the field and professional activities, also his pedagogical activities continue not only at Masaryk University, but also abroad. Besides, he is the founder and the head of the Discussion Club of the Faculty of Science, MU, and the annually held Quaternary seminars, highly evaluated by the professional community, have become a tradition. We wish Professor Musil that his good health and life vigour may also continue in further years.

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70th BIRTHDAY OF OLDŘICH FEJFAR

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Certainly, to everybody who knows Oldřich personally, it is hard to believe that he already attained his 70 – but it is true, indeed. Oldřich Fejfar, professor emeritus in Department of Paleontology, Charles University Prague, one of the Europe's best specialist in the Neogene and Quaternary mammals and a top expert in the Coenozoic biostratigraphy was born on 8 January 1931. He spent most of his life in Prague, capital of the Czech Republic, in the town rich in historical monuments and charmed with a specific atmosphere reflecting centuries of its eventful cultural and political history. Together with influences from a deeply educated environment of his parent family, all this shaped his personality and impressed it with patterns of a profound education and cultural background, including knowledge of classical languages, many aspects of fine arts and history, and – last but not least – a deep-rooted sense of truth and justice. All these qualities accompanied him throughout his life and often, particularly under the conditions of repressive political climate during the past regimes in former Czechoslovakia, made for him life rather difficult.

Oldřich has been keenly interested in science, and in zoology in particular, already when he was at the secondary school. Later he decided to study geology and paleontology. He attended the Faculty of Science of the Charles University in Prague in 1948 and finished it in 1954 with a thesis entitled "New records of fossil mammals from Zlatý kůň near Koněprusy and Chlum near Srbsko". Oldřich demonstrated here how useful are small mammals, particularly insectivores and rodents, for Quaternary stratigraphy. He focused on this topic also in most of his further studies. Oldřich was in scientific isolation in the course of the preparation of his thesis. Oldřich's university supervisor, Professor Dr. Josef Augusta, famous for his popular books on paleontology, did not provide much help. Neither he nor anyone else in Czechoslovakia was familiar with fossil mammals at that time, not to speak about micromammals. The situation was similar in other countries in the beginning of the 1950s. Oldřich's selection of the subject thus marked the beginning of a new era in paleomammalogy.

The selection was supported by discovery of several sites in close vicinity of Prague, which were very rich in remains of Quaternary vertebrates. First of all, it was the extensive complex of karst caves and fissures near the village of Koněprusy, in particular the site named C718, a complex infill covering a sedimentary sequence of a complete Early Pleistocene glacial cycle. Among other, Oldřich described from this site in 1966 two new index taxa of the late Early Pleistocene, viz. *Dicrostonyx simplicior* and *Macroneomys brachygnatus*, and first demonstrated in great details the aspects of the mammalian community development over an Early Pleistocene glacial cycle (1956, 1961, 1975 etc.).

In 1954 Oldřich attained his first professional position at the Quaternary department of the Geological Survey of Czech Republic, the position which he held until 1990. In the Geological Survey, he soon took part in several large-scale projects, such as detailed geological mapping of various regions of the then Czechoslovakia, reexamination of vertebrate fossil records available from this country, and their biostratigraphic dating. He developed standard prospecting techniques for potentially fossiliferous sites and for the collection of samples for their micropaleontological evaluation. He washed tons of sediments, discovered a number of fossiliferous sites and reexamined in detail almost all the sites mentioned in earlier literature. Oldřich Fejfar continued to focus on general problems of the mammalian biostratigraphy of Europe and on the major patterns of the Late Cenozoic faunal development. These topics were unclear and confused at that time. The Early Pleistocene and Late Neogene records used to be either arbitrarily ascribed to some of the earlier stages of the quadriglacialistic scheme or identified with a faunal type established in earlier literature, such as Cromerian, Villafranchian or Astian. Of these, only the Cromerian, biostratigraphic meaning of which was clarified e.g. by Florian Heller, was already then sufficiently well defined. Oldřich significantly helped to define the Cromerian using rich record of both large and small mammals from the Czech localities Koněprusy and Chlum. The remaining two faunal types, traditionally considered (even by the then valid standard definition of the Plio-Pleistocene boundary) as the transitional stages between the Pliocene and Pleistocene were established exclusively on the basis of large mammals. No data were available on small mammals, i.e. the groups shown by Oldřich to be of top biostratigraphic significance. The topical task was thus to discover a site of this age, where both large and small mammals of that age would occur in large quantity. Oldřich succeed. Already by the end of the 1950s he discovered two such sites: Hajnáčka near Fiľakovo (from where Kormos, 1917, described large mammals of Villafranchian age) and Ivanovce near Trenčín, both in SE Slovakia. During subsequent years, Oldřich undertook extensive excavations in both the sites, washed tons of tuffits and clays and obtained significant material, which he later described in detail in his PhD thesis (1964) entitled "The Lower Villafranchian vertebrates from Hajnáčka near Filakovo in southern Slovakia" and publisehd in a series of papers under the common title "Die plio-pleistozänen Wirbeltierfaunen von Hajnáčka

und Ivanovce (Slowakei), ČSSR" (1961a–c, 1966, 1970). In addition to a number of new taxa (including aberrant shrew genus *Allosorex* representing a separate subfamily Allosoricinae) and/or description of phylogenetically significant odontological traits in cricetids and arvicolids, Fejfar presented in these papers a detailed redefinition of respective transitional periods using evolutionary changes of in selected mammalian clades, reconsidering their biostratigraphic significance. Among other things, Fejfar demonstrated that the Villafranchian fauna is specific for a chronologically well defined period, being different from both Villanyian and Ruscinian, and that it thus represents a separate biostratigraphic unit.

Already in the 1960s, Oldřich became friends with a number of foreign colleagues, including Kazimierz Kowalski, Dénes Jánossy and in particular Miklós Kretzoi, whose 1956 monograph on the vertebrate faunas of Villanyi Mountains became one of the most important foundation stones of the modern Late Cenozoic biostratigraphy, the concept which Oldřich (1964,1976 etc.) supplemented with new data, and subsequently much refined both in both chronological and geographical respects. The results were published particularly in a series of papers on the Late Cenozoic stratigraphy written in collaboration with Wolf-Dieter Heinrich (1979, 1981, 1982, 1983, 1985, 1986, 1987, 1990, 1998) and other colleagues (1977, 1983, 1990, 1994, 1997, 1998).

Oldřich essentially contributed to the taxonomy of fossil voles and elucidated numerous taxonomic position of many problematic fossil taxa. He analyzed in detail specific features of tooth evolution in various arvicolid clades, chronological setting of respective morphogenetic events, and used the results of these studies (in close cooperation with Charles Repenning) in establishing a detailed biostratigraphic correlation of the Late Cenozoic of Europe with the rest of the Northern Hemisphere.

Simultaneously, already at the end of the 1950s, Oldřich turned his attention to Miocene mammals. A reexamination of the sedimentary complex in Devínská Nová Ves (Neudorf a. M.), Slovakia, and the newly discovered localities related to the Miocene marine sedimentation (Ořechov, Strakonice, Líšov; all in the Czech Republic) enabled him to correlate the stages of the marine biostratratigraphy of central Paratethys with the zones of the Miocene mammalian biostratigraphy (1972, 1974).

Thanks to his profound knowledge of early literature, Oldřich rediscovered long forgotten Tertiary sites, at which J. W. von Goethe, A. E. Reuss and E. Suess collected fossils in northern Bohemia in the 18th and 19th centuries. In these and in news sites, he discovered and investigated mostly in the 1970s and 1980s, such as Tuchořice, Dolnice 1–3 and Františkovy Lázně, he collected enormous amount of vertebrate remains. This material enabled Fejfar to study in detail patterns of the Neogene phylogeny of several rodent taxa (such as cricetids or eomyids, see e.g. his papers from 1974 and 1999) and to discuss details of the Neogene faunal development in central Europe. In the 1980s, Fejfar discovered in the NW Bohemian basin further sites, including first Bohemian localities of the Lower Oligocene age, Dvérce and Dětaň, and, in particular, the MN3 site Ahníkov-Merkur North, a lacustrine bed extremely rich in all vertebrate taxa. The latter site is in focus of Oldřich's current interest. Oldřich's excavations yielded in addition to mammalian remains numerous bones and bone fragments of other vertebrates. With his usual generosity, Oldřich has been offered these remains for study. Owing to this, he left his substantial mark also in such research fields, as paleornithology or paleoherpetology.

Oldřich Fejfar has gained already in the 1960s considerable international reputation. With political thaw in 1968 he could come in a closer contact with colleagues from countries laying west of the infamous Iron Curtain, and in 1969 he received the Alexander von Humboldt Award which enabled him to spend two years in the Paleontological Institute of the Munich University in Germany (under supervision of Prof. Richard Dehm). The fellowship enabled him to visit almost all of the prominent collections in western Europe and considerably deepen his familiarity with Tertiary mammals. Unfortunately, political repression in Czechoslovakia in the 1970s considerably limited his contacts with foreign colleagues and retarded his further professional career. The situation changed only with the "Velvet" revolution in November 1989, in which Oldřich took actively a part. At the beginning of 1990 he became full professor of vertebrate paleontology at the Charles University, Prague, and soon was appointed to chair the University's Department of Paleontology. He reestablished here courses in mammalian paleontology and stimulated a number of MSc. and PhD. student projects. Being not only a top expert in his research field, but also a humane personality, highly educated, communicative, considerate and friendly to all his students and colleagues, Oldřich has represented almost an ideal university teacher and has been greatly respected by all students and staff. Despite considerable administration and teaching duties connected with rearrangements of the Department Oldřich never stopped his scientific activity. Since 1990 he not only performed a number of field excursions and collection trips but published a number of essential contributions to various topics extending the initial framework of his research. It is beyond the scope of this brief essay to comment on all Oldřich's research interests. Although much of the field Oldřich's field research has been done in the territory of the former Czechoslovakia, he took part in paleontological expeditions to such diverse countries as Cuba, Libya, Peru and Mongolia. and described mammal fossils collected there. He also organized or attended numerous scientific meetings of which at least the first meeting of Biostratigraphy and paleoecology of arvicolid rodents in Rohanov 1987, organized by Oldřich, is to be mentioned as a beginning of a tradition of the workshops and meetings on that topic now followed by the Europan Quaternary Mammal Association. Until now, Oldřich authored 138 scientific contributions including 12 extensive monographs, elucidated a large number of scientific problems, described many new taxa and new fossiliferous sites. Without any overestimations, it can be said that Oldřich's contributions have substantially influenced development of the branch of Late Cenozoic terrestrial biostratigraphy and the current knowledge of the mammalian faunal evolution of that era.

Oldřich Fejfar is held in high esteem by his colleagues, friends and followers not only because of his scientific achievements, but also for his good-heartedness, his pronounced sense of humor and helpful attitude to his fellows. For the decades to come, we all sincerely wish Oldřich good luck, good health, good mood and lots of energy.

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IVO CHLUPÁČ SEDMDESÁTILETÝ

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V roce 2001 jsme oslavili dvě výročí, významná pro českou a světovou biostratigrafii a paleontologii: 150 let od narození profesora Otomara Pravoslava Nováka (*18. listopadu 1851 v Hradci Králové) a sedmdesátiny profesora Iva Chlupáče.

Již když jsem psal scénář a katalog Novákovy výstavy, uvědomoval jsem si četné paralely mezi doposud ne zcela doceněným Otomarem Novákem – a Ivem Chlupáčem, ovšem v časovém posunu století, se všemi důsledky, které vyplývají z vývoje společnosti, kultury, vědy a techniky v tomto pohnutém úseku našich dějin. Rád bych proto poukázat na určité společné rysy obou nevšedních osobností, které se hluboce zapsaly do historie českých přírodních věd.

Život a dílo O. Nováka jsme rekonstruovali z publikovaných prací, archivních dokladů a kusých literárních zpráv, někdy poněkud ověnčených dobovou gloriolou. Novák je pro nás *historickou veličinou*, bezprostředně navazující na barrandovskou éru a předčasně ukončenou zákeřnou smrtí 20. července 1883. Jeho aktivní vědecký život trval jen něco málo přes dvacet let.

Ivo Chlupáč je *živý člověk*, jeden z nás, v mém případě blízký přítel a spolupracovník od gymnaziálních let. Jeho otec mě dokonce učil na gymnáziu latinu a češtinu. Již padesát let krystalizují jeho vědecké poznatky, závěry a syntézy.

Oba byli ovlivněni Národním muzeem, i když každý jinak.

Novák přišel do muzea (tehdy Muzea království Českého) jako mladý volontér k Antonínu Fričovi. Základy geologie a paleontologie mu dal strýc Karel Feistmantel. Antonín Frič ho vědecky vychovával v muzeu i později na fakultě, a přiměl ho ke studiu trilobitů. Významně na něj působili Jan Krejčí a Eduard Suess. Záhy se seznámil s největší osobností naší paleontologické scény – Joachimem Barrandem, který mu byl učitelem a později jej ustanovil jedním z pokračovatelů svého nedokončeného díla.

Chlupáč jako mladičký student navštěvoval expozice v Barrandeu, kde určoval své sběry. Za gymnaziálních studií měl na něj vliv s muzeem spjatý Jaroslav Petrbok, jenž ho zasvěcoval to tajů jeskynního podzemí v Českém krasu, a později Ferdinand Prantl, i když zde došlo poměrně brzo k názorovým střetům. Z mimomuzejních osobností měl na Chlupáče největší vliv Bedřich Bouček, především prostřednictvím jeho geologického průvodce po pražském okolí, který si koupil jako desetiletý žák hned po vyjití prvního vydání knihy. Z období studií na fakultě nelze nezmínit tvůrčí vliv Odolena Kodyma, Radima Kettnera a Josefa Svobody.

Novák a Chlupáč mají v oblibě stejné skupiny paleozoických fosilií: trilobity, merostomáty, fylokaridy, různé záhadné členovce…

Pro oba je znalost jazyků a literatury klíčem k mezinárodní spolupráci. Oba se vyznačují nesmírnou pracovitostí, podobným pozorovacím talentem. U obou vycházejí první vědecké práce před dvacátým rokem života. Novák publikuje mezi prvními pracemi nálezovou zprávu ordovických fosilií z území Prahy, a také Chlupáč věnuje své první práce ordoviku.

Při revizi trilobitů zjišťuje O. Novák nesrovnalosti v korelaci Barrandova „silurského systému", věnuje se hercynské otázce a v roce 1880 publikuje kritické poznámky ke Kayserově fauně Harcu. Je mu tehdy necelých třicet let.

I. Chlupáč se začíná zabývat biostratigrafií lochkovského souvrství v jednadvaceti, a „hercynská otázka" determinuje – v širších souvislostech – jeho výzkum až do roku 1972, kdy byl – na základě jeho výzkumů a jeho zásluhou – mezinárodně schválen stratotyp hranice silur/devon v Barrandienu.

Když bylo Novákovi 36 let, stal se – po různých peripetiích – univerzitním profesorem na České univerzitě. Chlupáčovi se stejné cti dostává teprve ve zralém věku po dlouholeté vědecké práci v Ústředním ústavu geologickém – v roce 1992.

Tak jako O. Nováka, postihly i I. Chlupáče zákeřné choroby, které by v době Novákově znamenaly jistou smrt – a dokonce dvakrát v životě. U obou se staly stimulem k intenzivnější práci.

Ovšem – jsou zde rozdíly, jsou zde životní eventy, které nelze srovnat. Tím největším je, že Ivo poznal Olgu, která pro něj znamenala a znamená bezpečnou průvodkyni životem i vědeckou prací, přístavem v dobách bouřlivých a zlých. I když jeho první manželství ztroskotalo, stmelil všech svých pět dětí do jedné přátelské společnosti, která bohužel byla zasažena tragickou smrtí dvou dcer. Nyní v přátelské tradici pokračuje jeho šest vnoučat. Otomarovo manželství s Eleonorou záhy ztroskotalo, a nikdy mu nepřineslo to, co se někdy nazývá manželským zázemím.

Ivo Chlupáč se narodil 6. prosince 1931 v Benešově. Gymnázium navštěvoval v Praze-Břevnově. Již tehdy intenzivně exkurzoval s přáteli – nejdřív s Pavlem Röhlichem, pak s autorem této biografické črty a dalšími; s B. Boučkem asi od kvinty. Po maturitě byl přijat v roce 1951 na geologicko-geografickou fakultu University Karlovy, kde promoval s vyznamenáním v roce 1955. Téhož roku nastoupil do Ústředního ústavu geologického (dnes Českého geologického ústavu), a to do skupiny staršího paleozoika, kterou vedl J. Svoboda. V roce 1962 se stal kandidátem věd. V roce 1968 se účastnil příprav a vedení

exkurzí 23. Mezinárodního geologického kongresu, přerušeného okupací vojsk Varšavské smlouvy, proti které otevřeně vystupoval. Výsledkem bylo vyloučení z KSČ a znemožnění postupu, i když díky rozumnému vedení ústavu nebyla jeho vědecká práce přerušena. O doktorát věd se však mohl ucházet až po roce 1989. V geologickém ústavu setrval až do roku 1990, kdy se habilitoval a v roce 1991 dosáhl doktorátu věd. Již po nástupu na Přírodovědeckou fakultu byl jmenován vedoucím katedry geologie a paleontologie; univerzitním profesorem byl jmenován v roce 1992. Po odchodu do důchodu setrvává na Přírodovědecké fakultě jako profesor emeritus dosud.

Své první stratigrafické práce započal v ordoviku, kdy se věnoval hlavně královorskému a bohdaleckému souvrství. Po objevu společného výskytu graptolitů a devonských dakryokonaridních tentakulitů v lochkovském souvrství v někdejší podolské cementárně v roce 1952 se zaměřil na výzkum devonu. První vyšla studie o lochkovském souvrství a jeho faciích. Následovaly intenzivní práce v koněpruské oblasti, důkazy rifu včetně neptunských žil, facie pragu (1956–1957), a postupně podrobná biostratigrafická analýza a korelace všech devonských souvrství v Barrandienu. Definoval a uvedl do mezinárodního užívání čtyři stupně českého vývoje devonu (lochkov, prag, zlíchov, dalej). Své výzkumy podrobně prezentoval a obhájil v zahraničí, což nebylo vzhledem k prestižním stanoviskům některých zahraničních stratigrafů vždycky snadné.

Významná etapa Chlupáčova výzkumu se váže k definici hranice mezi silurem a devonem, jež v roce 1972 vyústila v mezinárodní přijetí jejího stratotypu na Klonku u Suchomast a v Karlštejně.

I. Chlupáč se však neomezil pouze na barrandienský devon. Paralelně řešil i otázky stratigrafie devonu a spodního karbonu na Moravě; mimo jiné objevil raně spodnokarbonskou faunu u Zbrašova u Hranic a popřel tak obecně přijímanou tezi o diskordanci mezi devonem a karbonem na Moravě. Zjistil přechodní vývoje moravského devonu a následně vyřešil paralelizaci drahanského vývoje a vývoje typu Moravského krasu. Zásadní je objev konkordantního uložení karbonu na famenu v Moravském krasu a nálezy fauny v metakvarcitech vrbenské skupiny Hrubého Jeseníku.

Na území Čech mimo Barrandien se Chlupáč zaměřil především na Podkrkonoší, kde již v roce 1963 nalezl spodnokarbonské trilobity na Velkém Vápenném u Jitravy a popřel tím kaledonskou stavbu Krkonoš. Později zjistil další nové výskyty devonu v jv. části Ještědského hřbetu. Důležitým výsledkem pátrání po fosiliích v rozmanitě metamorfovaných sedimentech je např. nález graptolitů a řešení stratigrafie v sedlčansko-krásnohorském metamorfovaném ostrově a nálezy ichnofosilií v pokrývačských fylitech u Železného Brodu.

Rozsáhlá je Chlupáčova výzkumná činnost v oblasti paleontologie. Jak sám říká, vždy se cítil spíše geologem než paleontologem. Pro řešení biostratigrafických problémů se však neobešel bez pečlivého paleontologického studia a publikoval i větší monografické práce. Oblíbil si především paleozoické členovce. Několik desítek prací je věnováno českým a moravským trilobitům, fylokaridním korýšům, eurypteridům a zvláštním ordovickým členovcům. Věnoval se našim nejstarším členovcům z brdského spodního kambria.

Kromě popisné paleontologie se věnoval ekostratigrafii; zabýval se faciální závislostí faun a definoval trilobitová a fylokaridová společenstva barrandienského siluru a devonu. Významné jsou jeho práce o goniatitech, částečně publikované s V. Turkem.

Kromě původní vědeckovýzkumné práce se intenzivně zabýval teoretickou stratigrafií a řešením biostratigrafické a regionálně geologické problematiky na mezinárodní úrovni. Sem patří zejména jeho práce jako editora v Lexique stratigraphique international (Massif de Bohême), četné články o mezinárodních zásadách stratigrafické klasifikace, spolupráce při vydávání International Stratigraphic Guide a kapitoly v souborných dílech věnovaných regionální geologii. Zpracoval četná hesla pro Naučný geologický slovník a byl editorem a spoluautorem významné české a anglické publikace Paleozoikum Barrandienu (1992, 1998).

Obsažnou sférou Chlupáčovy činnosti jsou geologické průvodce, zaměřené jak pro speciální účely různých konferencí, tak knižní, směřující především do Barrandienu, které si získaly u nás i v zahraničí zaslouženou popularitu. Zaujetí pro pedagogickou práci se promítlo do spoluautorství vysokoškolské učebnice historické a stratigrafické geologie (spolu s M. Mišíkem a I. Cichou) a do rozsáhlé publikace Geologická minulost České republiky, vydávané v letošním roce. Společně s Z. Kukalem se věnoval eventům v Barrandienu.

Studium geologických fenoménů přivedlo Chlupáče k potřebě chránit je, a to nejen pro vědu, ale i z estetických důvodů. Sem patří větší počet článků s ochranářskou tématikou, prosazování CHKO Český kras, návrhy ochrany geologických objektů na Sedlčansku, Ještědsku a v Jeseníkách, i energické vystupování proti postavení cementárny u Tmaně a těžbě vltavínů.

V souvislosti se snahami o moderní pojetí stratigrafie stal se I. Chlupáč předsedou Čs. stratigrafické komise, členem Komitétu pro hranici silur/devon při Mezinárodní stratigrafické komisi, členem mezinárodní Subkomise pro stratigrafickou klasifikaci a stratigrafii devonu a dalších mezinárodních uskupení, řešících stratigrafickou problematiku. Od gymnaziálních let je členem České společnosti pro mineralogii a geologii, po roce 1990 byl zvolen členem německé akademie věd „Leopoldina".

O významu vědeckého pracovníka a uznání výsledků jeho vědecké práce svědčí i názvy taxonů, které nosí jeho jméno. Během let byl takto Ivo Chlupáč poctěn nejméně ve dvaceti případech. Byli to paleontologové naši i zahraniční, a jeho jméno zdobí druhy a rody nejrůznějších skupin. Jen tak namátkou: trilobiti *Kolihapeltis chlupaci* Šnajdr, 1960 (spodní devon Barrandienu), *Cornuproetus* (*C.*) *chlupaci* G. Alberti, 1967 (spodní devon Maroka), *Chlupacula* G. Hahn et Wunn Petry 1983 z karbonu Německa, Polska, Rakouska, Anglie, Španělska a Malaysie, plži *Coelocaulus chlupaci* Horný, 1953 ze siluru Barrandienu, *Chlupacispira* Blodgett et Rohr, 1989 ze spodního devonu USA, goniatit *Chlupacites* Becker et House, 1994 z emsu-eifelu Evropy a severozápadní Afriky, dakryokonaridní tentakulit *Nowakia chlupaciana* G. Alberti, 1979 ze středního devonu Barrandienu a severozápadní Afriky, ramenonožci *Chlupacitoechia chlupaci* Havlíček, 1956 ze spodního

devonu Barrandienu, *Chlupacina* Havlíček et Racheboeuf, 1979 ze středního devonu Barrandienu, rostlina *Pseudosporochnus chlupaci* Obrhel, 1959 ze středního devonu Barrandienu.

V osobnosti I. Chlupáče se sloučily vlastnosti a mimořádné schopnosti, které se většinou vyskytují vzácně a osamoceně. Především je to *láska k přírodě* a *zkamenělinám*, která se začala rozvíjet snad již od tří let věku, kdy se setkal se svým prvním trilobitem. *Studijní, jazykové* a *vyjadřovací schopnosti* získané v rodině gymnaziálního profesora napomohly mu již ve školním věku vytvořit si představu o stavu poznání a o literatuře v geologických vědách, a do té doby spadají i jeho první publikované samostatné práce. Další obor, možno-li tak říci, bylo *sběratelství zkamenělin*, vytváření muzejně organizované sbírky dokladů vlastního výzkumu, které ho doprovází po celý život. Tyto sbírky se pochopitelně časem staly součástí sbírek veřejně spravovaných, zejména v Českém geologickém ústavu a v Národním muzeu, ale nadále se rozšiřují a doplňují. Biostratigrafické výzkumy i sbírání zkamenělin bylo spojeno se značným *fyzickým úsilím, houževnatostí* a *svědomitostí práce*, vlastnostmi, které prokazoval již v rozáhlých výkopech v ordoviku a devonu a např. při riskantním slaňování a podrobném zkoumání a kreslení severní stěny Císařského lomu na Zlatém koni u Koněprus. Zevrubné poznání profilů z autopsie vedlo k vytvoření *moderní metodiky výzkumu profilů* a ovlivnilo mezinárodní myšlení v biostratigrafii. Dalšími vlastnostmi jsou neobyčejná *skromnost, objektivita a kritičnost*, uplatňovaná při vlastní práci a výzkumech jiných pracovníků. Nelze opomenout schopnost *lapidárně, přesně* a *srozumitelně formulovat* dosažené závěry, a *rigorózní bojovnost* při jejich obhajování a při obhajování *nového*, zejména na mezinárodním fóru, kdy musel leckdy vynaložit hodně *úsilí i diplomacie* při oprávněném prosazování českých objevů, zvláště u našich sousedů. Konečně nemůžeme nezmínit výjimečné (snad zděděné) *pedagogické schopnosti, přátelský vztah ke studentům* a *dar poutavého vyprávění*, osvědčeného při přednáškách, exkurzích i populárních rozhlasových relacích.

Skutečnost, že si připomínáme 70. Ivovy narozeniny, naprosto neznamená, že sumarizujeme jeho život a práci. Je to jen příležitost uvědomit si včas jeho lidský vklad a vědecký přínos a popřát mu do dalších let možnost dál pevně svírat geologické kladivo a kompas, směřující k dalším objevům.

Když píšu tyto řádky, vybavují se mi nesčetné příhody, často nezbedné, které jsme spolu prožili, od školních dob až do pozdějšího věku. Vzpomínám na jeho „protimatematické zásluhy" v Řádu matematických rytířů na gymnáziu, na naše silvestrovské nebo novoroční výpravy do Barrandienu, na chvíle posezení při sklenici lochkovského nebo suchomastského piva, na návštěvy skalníků v Černé rokli pod Kosoří, i na válení balvanů z Budňanské skály a různá setkání se sveřepými hlídači a jim podobnými fenomény, které tak mistrovsky zpodobnil ve známé monografii „Hlídačové země české, jejich systém, výskyt a určování", kterou napsal společně se dvěma spolužáky již na gymnáziuu. Zde se snad nejlépe projevil jeho zvláštní, vytříbený humor, který mu pomáhal i mnohdy jindy v půtkách s byrokracií a samolibým autoritářstvím.

Mnohdy jsem přemýšlel, z čeho Ivo čerpá to neobyčejné badatelské nadšení, čím kompenzuje čas, věnovaný vědecké práci. Myslím, že jsem konečně pochopil, že to bylo a je *upřímné okouzlení tajemnem přírody*. Vždyť i sbírání a studium zkamenělin je vlastně fantastická exkurze do tajemného světa, který se stále a v nejpodivnějších proměnách prolíná s naší současností. A Ivova fantazie, podložená poznáním, mu umožňovala nořit se do příboje křídového moře u Vrapic a sbírat žraločí a rejnočí zuby, nebo vnímat sílu vulkánu na Vinařické hoře. Podobné pocity prožíval, když v mysli sestupoval do nitra živého koněpruského útesu a viděl krajkoví mechovek, hlavonožce číhající na kořist a pomalu proplouvající žralokovité macherakanty, nebo když zde objevoval neptunské žíly. Vábilo ho jeskynní přítmí, kde v mihotavé záři karbidové lampy nalézal kosti a zuby jeskynních hyen. Vábilo ho tajemné a nepoznané – gigantičtí eurypteridi, podivuhodní fylokaridi, náš nejstarší členovec *Kodymirus* ze spodního kambria, tragickou pověrou opředená *Furca*, podivuhodná *Duslia* a záhadná *Tuzoia*...

A jako se prvohorní scenerie prolínaly s utěšenou pahorkatinou Barrandienu, tak se mu občas, za zvlášť příhodných atmosférických podmínek, ukázaly i víly.

Stejně jako život v devonu – rodí se, žije a umírá i náš. Dříve než mohl vyjít tento článek, odešel Ivo 7. listopadu 2002. Do poslední chvíle bojoval se silnějším soupeřem. Překonával bolest, horečně psal, dokončoval práce.

Při jednom z posledních setkání mi řekl: „Proč musím končit. Mám ještě tolik práce, a mám vědeckou práci tak rád..."

Svým dílem dosáhl do hloubek devonského času a přinesl Poznání, jímž se navždy zapsal do dějin geologie a paleontologie.

Odešel mimořádný Člověk.

IVO CHLUPÁČ SEPTUAGENARIAN

Summary

In 2001 we celebrated anniversary of the birth of two outstanding personalities of Czech palaeontology and geology: 150 years since the birth of Otomar Pravoslav Novák (18th November 1851) and the 70th birthday of Ivo Chlupáč (6th December 1931). Both men have made extraordinary contributions to the development of Czech palaeontology and stratigraphy. Their lives, methods of study and the results illustrate well the progress of the geological sciences during the second half of the 19th and the second half of the 20th centuries. Originally, both were more or less connected with the Czech or National Museum, and they both crowned their career with a professorship at Prague (Charles) University. They both initiated their research within the Ordovician of the Barrandian, and they both continued with the problem of the Silurian/Devonian boundary – the so-called "Hercynian question". While Novák carried on pure palaeontological research, Chlupáč engaged himself mostly in the stratigraphy of the Devonian and Lower Carboniferous. Both loved trilobites and various obscure and weird arthropods, mainly crustaceans. Each devoted a few papers to cephalopods.

Ivo Chlupáč was born in Benešov on December 6th, 1931. He met his first trilobite when only three years old. He graduated at the high school in Prague in 1951. During this time he was intensively interested in field excursions, collecting fossils and studying literature, largely influenced by Prof. B. Bouček. In 1951 he entered the University (Faculty of Geology and Geography) and, after finishing

University, he was employed in the Central Geological Survey (now Czech Geological Survey) in 1955. Here he worked in the research group of J. Svoboda, taking part in the making of new detailed geological maps and stratigraphic research in general. In 1990 he became the docent and a two years later the professor and leader of the Department of Geology and Palaeontology in the Faculty of Natural History, Charles University, Prague. He is still active as professor emeritus.

He started his stratigraphical works in the Upper Ordovician. Later, though still during his university studies, he found graptolites together with dacryoconarid tentaculites in the Lochkov Formation. This draw his attention to the problem of the Silurian/Devonian boundary and to the biostratigraphy, facies development and international correlation of the Lower and Middle Devonian in the Barrandian. Gradually, he intensively studied the Koněprusy Limestone, demonstrating the Koněprusy reef, including the neptunean dykes, and interpreting the development of facies synchronous with the Koněprusy Limestone. Subsequently, he carried out a detailed palaeontological and stratigraphical analysis of all Lower and Middle Devonian formations in the Barrandian. He defined and introduced four stages of the Czech development of the Devonian – Lochkovian, Pragian, Zlíchovian, and Dalejan. All results were published in detail and presented on the international scene.

An important stage of Chlupáč's investigation concerns the definition of the Silurian/Devonian boundary which finally gained international acceptance of its stratotype at Klonk near Suchomasty, and the Budňany Rock at Karlštejn in the Barrandian, Bohemia.

Ivo Chlupáč, however, did not limit himself to the Barrandian in central Bohemia. Simultaneously he resolved various problems concerning Devonian and Carboniferous stratigraphy in Moravia. In discovering the Lower Carboniferous fauna near Zbrašov near Hranice, he disclaimed the widely accepted thesis about the unconformity between the Devonian and Carboniferous in Moravia. A fundamental find was a conformable succession of Carboniferous sediments on the Famenian in the Moravian Karst.

In territories of Bohemia located outside the Barrandian he draw attention to the Krkonoše foothills where he found Lower Carboniferous trilobites near Jitrava, thus disclaiming the Caledonian orogeny in the Krkonoše Mts. Searching for fossils in various metamorphosed series, he found graptolites in the Sedlčany-Krásná Hora metamorphic complex and ichnofossils in the slates near Železný Brod.

Chlupáč's work in palaeontology and ecostratigraphy is extensive. Although, as he himself says, he feels himself more a geologist than a palaeontologist, he has published many papers devoted to Czech and Moravian Devonian and Carboniferous trilobites, phyllocarid crustaceans, eurypterids and various obscure Ordovician arthropods. He also studied Czech Lower Cambrian arthropods. Also notable are his papers concerning goniatites, partly published with V. Turek, and papers bearing on facies relation of various fauna, mainly trilobite and phyllocarid communities.

Besides his original research, Chlupáč is also intensely interested in theoretical stratigraphy and regional geology; e.g. as editor for Lexique stratigraphique international (Massif de Bohême), collaborator for the International Stratigraphic Guide, and author of many chapters in regional compendia. In this connection he became the chairman of the Czech Commission for Stratigraphy, a member of the Silurian/Devonian Committee at the International Commission on Stratigraphy, a member of the International Subcommission on Stratigraphical Classification and Stratigraphy of the Devonian System. In 1990 he was elected a member of the German Academy of Science "Leopoldina".

His speciality is the production of guides, including popular, illustrated books. His largest, quite recent textbook, concerns the geological past of the Czech Republic. He has made also important contributions to conservation (protection of geological phenomena, against devastation of localities by cement factories, etc.).

His contribution to research in the Lower Palaeozoic is witnessed by the many fossils of various groups, both genera and species, named after him. Some of these are given in the Czech text.

Outstanding results of research are connected with an extraordinary personal character in our honoured friend. He came from a professor's family, and was endowed with language skills and the ability to develop and express ideas. Since his boyhood, he has been a keen collector of fossils; his collection, museologically organized, became the basis for his future research. His fieldwork is characterised by physical endeavour. He is tenacious and conscientious, but modest, objective, and severe both to himself and to the work of others. His papers are tersely, exactly, and clearly formulated. Typical is his endeavour and diplomacy when arguing for new thoughts and discoveries. Finally, he is a teacher, with a friendly relationship to young people and students, and an engaging narrator.

Prior to the publication of this article, Prof. Ivo Chlupáč passed away on 11th November, 2002. His death is a great loss for geology and palaeontology. He will be remembered with gratitude by many research students and all people who knew him.

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ROUND ANNIVERSARY OF RNDr. ONDREJ SAMUEL, DrSc.

ADRIENA ZLINSKÁ[1)]

Geological Survey of the Slovak Republic, Bratislava



He was born in February 10, 1931 in Palárikovo, near Nové Zámky. In 1945 he entered secondary school in Nové Zámky. After graduating (1948) he was accepted on business college which he finished with award in 1952. After passing differential exams from grammar-school subjects he was accepted on Geological-Geographical Faculty of Comenius University in Bratislava where he graduated in 1956.

During the last year of the study he was in position of D. Andrusov's assistant. Since 1956 to 1994 he was employed at the Dionýz Štúr Institute of Geology, where he was in position of deputy director (1972–1982), head of paleontology department (1982–1983) and head of biostratigraphy department (1982–1993). At the GÚDŠ he was also elected to the position of chairman of the convocation (1980–1994) and editorial board (1972–1994). Since 1963 to 1986 he was a scientific redactor of editorial series Západné Karpaty (Western Carpathians), sequence Paleontológia (Paleontology), long-time scientific redactor of the edition Geologické práce – Správy (Geological Works – Reports) (1964–1997), Mineralia Slovaca (1973–1995), Časopis pro mineralogii a geologii (Magazine for mineralogy and geology) or Časopis Českej geologickej spoločnosti (Magazine of the Czech Geological Association) (1985–1994).

Thanks to his wide scientific and management abilities he was a member of various scientific institutions. Within the scientific board for sciences of the Earth and space of SAV (Slovak Academy of Science) he worked for the commission for geology and geography, he was a chairman of terminological commission and deputy chairman of Czechoslovak Stratigraphical Commission of ČSAV (Czechoslovak Academy of Sciences) board for geology and geography, as well as member of common scientific board of ÚÚG (General Office of Geology) and GÚDŠ and Czechoslovak (and Slovak) National committee. Beside scientific activities he was also active in organizing of various scientific undertakings, as for example, X. Anniversary Meeting of CBGA (Carpathians – Balkan Geological Association) in Czechoslovakia (1973), XIII. National Geological Conference of the Slovak Geological Society (SGS). It is especially important to mention his meritorious activities for the Slovak Geological Society. He has become its member since 1960 and since 1974 he was appointed secretary, then deputy chairman and since 1982 to 1994 chairman. Since 1983 to 1995 he was a president representing CSFR (since 1993 Slovak Republic) in CGBA, where he was member of the International Subcommittee for Paleontology. He was chairman of the board for defense of candidate dissertation thesis (CSc.) for the specialization paleontology and alternating chairman of the board for defense of doctoral dissertation thesis (DrSc.).

In 1964 he defended his candidate dissertation thesis (CSc.) on theme "Microbiostratigraphy of external and internal flysch of the eastern Slovakia, Paleogene of Klippen Belt and Central-Carpathians Paleogene". The degree doctor of science (Dr.Sc.) he defended in 1972 in Bratislava.

During his scientific-research activities his major specialization was in stratigraphy of Paleogene, Cretaceous and later also Triassic as well as paleontology of foraminifers. The published monographs about these problems represent so far the most complex review and stratigraphic value of foraminifers of the Western Carpathians. He described almost 40 new taxons that validity was in most cases accepted also by the prestigious monograph Foraminiferal Genera and Their Classification (by Loeblich – Tappan), published in New York (1988). His works have had also influence upon improvement of accuracy of the flysch sequences and the Klippen belt on Slovak territory, what also improved theory about paleogeographic and also tectonic development of the Western Carpathians. Important feature of his published works is also comparison of planktonic foraminifers with other fossil series (giant foraminifers, nanoplankton, palynology) and biozoning of the Cretaceous and Paleogene, what enables interregional stratigraphic parallelism and correlation with the international geochronological scale.

Beside monograph works he has also essential portion on publishing of the three volumes of the Stratigraphic dictionary (1983, 1985, 1988), which he not only edited but he was also as one of the major authors. These three volumes mean the first litobiostratigraphic classification of the Western Carpathians systems. As suitable part of the Stratigraphic dictionary is also the first (1980) and also the second (1987) publishing of Chronostratigraphic and synoptic table reflecting the present state of the chronostratigraphy in world-wide scale. Beside mentioned works he also participated on two volumes of The

Encyclopedia of geological sciences (1983) and The Encyclopedia of Slovakia. As a result of the long lasting activity of the terminological commission there is a unique work: Reference-terminological dictionary (2000) for specialization paleontology. It contains 3500 entries.

His scientific-research activities were awarded on an international forums, for example, during the scientific meeting about Eocene in Hungary, where he was honored by medal for his contribution in solving problems of microbiostratigraphy of Paleogene in Europe. For his extensive international cooperation in Middle Europe he was awarded by honor plaque of the Hungarian Geological Institute, Polish Geological Institute (1970), Central Geological Institute in Prague (1979), as well as by honor memberships in the Poland Geological Society (1990), Czechoslovak Society for Mineralogy and Geology at the ČSAV (1990), Slovak Geological Society (1997) and the Hungarian Geological Society (1998). The committee of SGS awarded him by medal of Ján Slávik (1982) for his extensive activities in the Slovak Geological Society.

His work was awarded also by the national authorities. He was awarded by the governmental departmental award "the best worker of the geological survey" (1969) and in 1971 he was awarded by state governmental departmental award for his loyalty to the employer. He was awarded by Dionýz Štúr plaque for his development of geology (1974) and GÚDŠ honor plaque (1980). For his development of the scientific specialization he was awarded by the Dionýz Štúr golden plaque, and for his contributions in the Earth sciences, by the Slovak Academy of Sciences (1991). In 2000, at the occasion of 60th Anniversary of founding of the State Geological Institute of Dionýz Štúr he was awarded by the medal for development of geology and propagation of Slovakia abroad.

He published the results of his research works in about 250 publication in national and international magazines and publications from various symposiums and meetings, numerous (about 200) non published research reports as well as in 5 monograph works in which he presents so far the most complex description and stratigraphic value of the Western Carpathian foraminifers. In this work he describes 40 new taxons:

1. Foraminifera of the Western Carpathians-Cretaceous (J. Salaj – O. Samuel, 1967; pub. GÚDŠ, in German).
2. Microbiostratigraphy and Foraminifera of the Slovak Carpathian Paleogene (O. Samuel – J. Salaj, 1968; pub. GÚDŠ).
3. The Geology of the Eastern Slovakia Flysch (B. Leško – O. Samuel, 1969; pub. SAV, in Slovak),
4. Microfauna and Lithostratigraphy of the Paleogene and adjacent Cretaceous of the Middle Váh valley (West Carpathian) (O. Samuel – K. Borza – E. Kőhler, 1972; pub. GÚDŠ).
5. Triassic Foraminifera of the West Carpathians (J. Salaj – K. Borza – O. Samuel, 1983; pub. GÚDŠ).

A very valuable feature of the mentioned works is comparison of planktonic foraminifera with other fossilized groups, mainly large foraminifera and biozoning of Cretaceous and Paleogene on the basis of planktonic foraminifers that enables intercontinental parallelism and correlation with international geochronological stratigraphic scale, what gives to the works the European and global weight in the microbiostratigraphic field.

The value of the published works is also enhanced by the fact, that they deal with the synonymics and taxonomic value of species, that were parallel described in the former Soviet Union and in the western countries. This critical approach has given to his publications special international feature, what is best proved by great international interest about the results of his researches and by numerous quotations practically in all prestigious scientific magazines.

The research works of RNDr. O. Samuel, DrSc., represent certain milestone in the development of micropaleontology in our country. They influenced present opinions on stratigraphy and in such a way also on geology, tectonics and paleogeography of Cretaceous and Paleogene of the Western Carpathians of Slovakia. His results have exceeded regional frame and they are contribution to this scientific discipline in an international level.

On the behalf of the geological community, we wish all the best to the jubilant in the next years.

Prior to the publication of this article, RNDr. Ondrej Samuel, DrSc., passed away on 20. 12. 2002.

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VÝZNAMNÉ ŽIVOTNÍ JUBILEUM Prof. RNDr. BLANKY PACLTOVÉ, CSc.

ZLATKO KVAČEK, OLDŘICH FATKA

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Léta běží a nedají se zadržet. Také 75leté životní jubileum Blanky Pacltové, emeritní profesorky Přírodovědecké fakulty Univerzity Karlovy přišlo, a jsme všichni rádi, že jubilantku zastihlo uprostřed tvořivé badatelské práce.

Profesorka Blanka Pacltová se narodila v Nechanicích 18. října 1928. Své dětství prožila na zemědělské usedlosti v Kratonohách u Hradce Králové, kam se dodnes často vrací i dnes a udržuje, seč jí síly stačí, rodinnou chalupu. Střední školu už vychodila v Praze, s přestávkou v době okupace, kdy byla totálně nasazená na práci ve Škodovce. Po maturitě v roce 1948 se vrhla do obnovování českého vysokého školství, zejména prostřednictvím jeskynní sekce Klubu turistů, které se stala členkou. Na nově zřízené Přírodovědecké fakultě Univerzity Karlovy pod vedením profesorů Odoléna Kodyma a Radima Kettnera studovala v letech 1948 až 1952 nejprve obory chemie a biologie, později paleobotaniku. Ještě během posledního roku studia nastoupila jako asistentka prof. Němejce na katedru paleontologie a tomuto pracovišti zůstala věrná až do doby svého odchodu do důchodu. V roce 1952 získala doktorát přírodních věd a po dalších pěti letech i vědeckou hodnost kandidáta věd. V roce 1959 se habilitovala pro obor mikropaleobotaniky předložením a obhájením habilitační práce na téma paleopalynologie jihočeských pánví. Úředního ustanovení docentkou se dočkala v roce 1963. Jsou nám známy okolnosti, které nedovolily její profesuru v době politické represe v době před rokem 1989. A tak její jmenování profesorem na přírodovědecké fakultě UK bylo tak odsunuto až do roku 1991.

Prof. Pacltová svým působením na přírodovědecké fakultě v podstatě založila českou paleopalynologickou školu. Navázala zprvu na práci prof. K. Rudolpha ve výzkum rašelin. Za přispění prof. O. Kodyma vybudovala palynologickou laboratoř včetně univerzálně vybavené knihovny. Vychovala celou generaci českých specialistů zaměřených na mikropaleobotanický výzkum prekambria a staršího paleozoika (dr. M. Konzalová, dr. M. Vavrdová, doc. O. Fatka, dr. P. Dufka, dr. J. Bek), na výzkum křídy (dr. M. Svobodová, dr. Pátová), terciéru a kvartéru (dr. M. Konzalová, dr. M. Boháčová, Mgr. Dlouhá). Byla vyhledávanou školitelkou a konzultantkou zahraničních pracovníků (např. prof. J. Doyle, USA, prof. Pflug, SRN, prof. Norris, USA) a působila jako školitelka doktorandského studia.

Od roku 1955 do svého penzionování vedla speciální přednášky a cvičení v oboru mikropaleobotaniky a sestavila učební texty pro tento obor (Pacltová 1990). Rovněž se podílela na sestavení učebních textů všeobecné paleontologie (Pokorný et al. 1992).

Svou rozsáhlou vědeckou činností a spoluprací s prof. Fr. Němejcem položila základ ke komplexnímu paleobotanickému výzkumu řady třetihorních oblastí v bývalém Československu. Monograficky zpracovala třetihorní sporomorfy z mydlovarského souvrství jihočeských pánví, senonských uloženin klikovského souvrství téže oblasti a započala paleopalynologický výzkum slovenských třetihor. Mezinárodní ohlas si zejména získaly její práce z oblasti českého cenomanu a její příspěvky k vývoji krytosemenných rostlin (také v rámci monografického zpracování skupiny Normapolles – Góczán et al. 1967). Vytvořila systém paleofaciálního hodnocení spekter palynomorf české křídy. V oboru křídové palynologie se stala uznávanou osobností a expertkou, vytvořila si řadu osobních kontaktů s význačnými zahraničními pracovníky, jako prof. Hughes, Cambridge, prof. Krutzsch, Berlin, prof. Zaklinskaya, Moskva, prof. Méon, Lyon a jiní. Zvláštní pozoruhodné výsledky zveřejnila v oboru prekambria a paleopalynologickém výzkumu krystalinika.

Přehlédneme-li publikační činnost jubilanky, zahrnující přes 200 původních prací, článků a recenzí, vyplyne nám její široký badatelský záběr postihující téměř všechny geologické útvary a skupiny rostlin po stránce mikrospór. Při plnění svých vědecko-výzkumných a pedagogických povinností se prof. Pacltová neúnavně věnovala spolkové činnosti. Je členkou řady našich vědeckých společností, a zejména v bývalé Čs. společnosti pro mineralogii a geologii zastávala řadu let funkci člena výboru společnosti a byla předsedkyní oborové skupiny paleontologie. Působila i v mezinárodních organizacích, jako členka rady International Palaeontological Union, International Commission for Palynology a Origin of Life. Její dlouholeté působení v oboru bylo oceněno řadou vyznamenání a čestných uznání, z nichž si snad nejvíce dnes považujeme medaili prof. Szafera udělenou Polskou akademií věd v roce 1986.

Jménem všech palynologů přejeme naší paní profesorce mnoho dalších badatelských úspěchů v jejím zamilovaném oboru.

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OCCURRENCE OF CALCAREOUS NANNOPLANKTON IN THE PANNONIAN SEDIMENTS OF SLOVAKIAN NEOGENE BASINS

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The Neogene basins of Slovakia (Vienna, Danube and East Slovakian basins) represent northern bays of the Central Paratethys. During the Early and Middle Miocene a marine sedimentation environment existed in these basins. At the end of the Middle Miocene (Sarmatian) and specifically during the Late Miocene (Pannonian – Pontian) an uplift of the Carpathian mountain range took place, which produced the area's isolation and consequently gradual salinity decrease of the environment. Water salinity decrease caused an extinction of some groups of organisms as well as a qualitative change in communities of organism groups unable to adapt to this change.

During the Pannonian, the environment of these basins were inhabited mainly by molluscs (gastropods, bivalvia) and by ostracods. Stratigraphy of the area has been also based on these organisms.

In the 60-ties of the last century, there was firstly detected an occurrence of calcareous nannoplankton in Hungary and a new genus *Perforocalcinella* was defined (Bóna 1964).

During the next years, other new genera of calcareous nannoplancton, namely *Noelaerhabdus* (Jerković 1970), *Bekelithella* (Bóna and Gál 1985) and *Praenoelaerhabdus* (Mihajlović 1993) have been described. These genera represent endemic forms characteristic of the Pannonian region. Based on stratigraphic distribution of individual species of the mentioned genera, Marunteanu (1997) created a local scale in the eastern part of the Pannonian basin. The scale consists of three biozones.

1. Biozone Noelaerhabdus bonagali (E zone of the Pannonian)

2. Biozone Noelaerhabdus bozinovicae (C–D zone of the Pannonian)

3. Biozone Praenoelaerhabdus banatensis (A–B zone of the Pannonian)

In the Slovak part of the Danube Basin, it was possible to identify the biozone Noelaerhabdus bozinovicae in sediments of the Pannonian zone C–D. In these sediments, a community of calcareous nannoplankton with the species *Noelaerhabdus bozinovicae* Jerković, *N. jerkovici* Bóna et Gál, *Coccolithus* ex gr. *pelagicus* (Wallich) Schiller, *Thoracosphaera deflandrei* Kamptner and *Reticulofenestra pseudoumbillica* (Gartner) (Raková in Nagy *et al.* 1995) has been defined.

In the Lower Pannonian sediments of the East Slovakian Basin, presence of the species *Discoaster* cf. *hamatus* Martini, characteristic of the standard NN9 zone, has been identified. Beside this species also *Reticulofenestra* aff. *productella* (Bukry), *Minylitha? convalis* Bukry and others, have been distinguished.

In the Pannonian E zone of the Vienna Basin, acme zones of the species *Reticulofenestra productella* (Bukry) and *Syracosphaera pulchra* Lohmann have been detected. Presence of the species *Reticulofenestra productella* (Bukry) indicates the zone NN10–NN21, most probably NN 10–NN 11 zone.

The findings shown above confirm the fact that during the Pannonian, sea ingressions into the Pannonian lake took place, either from the Mediterranean area or from the East Paratethys.

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STATISTICAL EVALUATION OF CONULARIIDS OF THE LOWER PALAEOZOIC OF THE PRAGUE BASIN

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Abstract: This work shows three groups of conulariid exoskeleton characteristics on selected conulariid species of the Lower Palaeozoic of the Prague Basin. Tables sum up usual measurements of characteristics and their variability which can influence systematics of the group.

INTRODUCTION

Conulariids of the Lower Palaeozoic of the Prague Basin have not been evaluated from the biometric point of view yet. In Czech Republic there is a great amount of specimens of this group. For this study 356 conulariid specimens were used. This material is housed in Czech Geological Survey in Prague, National Museum in Prague, Faculty of the Nature Sciences of Charles University, Museum of West Bohemia in Pilsen and Museum of Dr. B. Horák in Rokycany.

Czech authors Želízko (1911, 1913) and Bouček (1928, 1939) mentioned measurements of the main morphological features in descriptions of individual species. The number of the species they observed was not big enough to get some important information about variabilities within species.

The distinctive morphological variability of conulariids causes the uncertainity in the determination of specimens. This study should give an idea of usual measurements of morphological features of Bohemian Lower Palaeozoic representatives of the family *Conulariidae* Walcott, 1886, their variability and its influnce on species establishing.

METHODOLOGY

Conulariids are quite rare fossils in fossil record and some species are represented only by several specimens. These amounts are not usually useful for statistical evaluation.

Because of this fact the selection of appropriate specimens for study was made first.

Minimaly one representative from each genus or subgenus is evaluated. Tab. 1. shows species selected from individual genera and subgenera and numbers of studied specimens.

To get maximal information there were established three main groups of characteristics: taphonomical data, biometric characteristics and group of additive characteristics related to the exoskeleton.

Taphonomical data include exoskeleton preservation expressed by the number of faces; cross section preservation expressed by the number of faces; type of fossil – mould, nucleus; presence of exoskeleton material – periderm.

Biometric characteristics are the most important features of the exoskeleton usually used for determination of various

Tab. 1. Conulariid species selected for study.

Genus / Subgenus	Species	Number of specimens
Subgenus *Archaeoconularia* Bouček, 1939	*Conularia (Archaeoconularia) fecunda* *Conularia (Archaeoconularia) insignis*	36 78
Subgenus *Mesoconularia* Bouček, 1939	*Conularia (Mesoconularia) fragilis*	7
Subgenus *Plectoconularia* Bouček, 1939	*Conularia (Plectoconularia) hanusi* *Conularia (Plectoconularia) proteica*	3 15
Genus *Exoconularia* Sinclair, 1952	*Exoconularia consobrina* *Exoconularia exquisita*	21 50
Genus *Metaconularia* Foerste, 1928	*Metaconularia anomala* *Metaconularia imperialis* *Metaconularia kettneri*	39 61 4
Genus *Pseudoconularia* Bouček, 1939	*Pseudoconularia grandissima*	21
Species with the uncertain systematical position	*Conularia rugulosa*	21

Tab. 2. Taphonomical data and additive characteristics related to the exoskeleton.

TAXON	type offossil (M/N)	type of preservation	number of faces/ percentual amount of samples (%)	cross section (% of samples)	number of faces	periderm (% of samples)	colour	apex (% of samples)	shape of apex	aperture (% of samples)	number of lappets
Genus *Conularia* Miller, 1818											
Conularia rugulosa	0/15	fragment	4/100	100	4	0	0	0	0	0	0
Subgenus *Archaeoconularia* Bouček, 1939											
Conularia (Archaeoconularia) fecunda	6/30	fragment	4/39	81	0,25	33	LG, DG	0	0	8	4
Conularia (Archaeoconularia) insignis	62/16	fragment	1/36	9	0,5	54	B, GB	0	0	4	4
***Subgenus Mesoconularia* Bouček, 1939**											
Conularia (Mesoconularia) fragilis	1/6	fragment	4/72	71	4	100	G, W	0	0	0	4
Subgenus Plectoconularia Bouček, 1939											
Conularia (Plectoconularia) hanusi	3/0	fragment	2/65	0	0	100	D, Br	0	0	0	0
Conularia (Plectoconularia) proteica	15/0	fragment	2/47	0	0	87	B, RBr	0	0	6	2
Genus Exoconularia Sinclair, 1952											
Exoconularia consobrina	9/12	fragment	4/50	53	1	5	B	0	0	5	1
Exoconularia exquisita	27/23	fragment	1/31	30	4	82	DG, BrB	6	oblique	2	1
Genus *Metaconularia* Foerste, 1928											
Metaconularia anomala	0/39	fragment	4/37	89	4	0	0	23	narrow sharp	21	4
Metaconularia imperialis	53/8	fragment	4/37	8	4	41	B, DG BrV	0	0	0	0
Metaconularia kettneri	1/4	fragment	4/57	4	4	25	DG	0	0	0	0
Genus *Pseudoconularia* Bouček, 1939									0		
Pseudoconularia grandissima	20/1	fragment	4/50	4	0,25	100	LG, Br	0	0	0	0

Legend: *Type of fossil*: M = mould, N = nucleus; *Colour*: B = black, Br = brown, BrB = brown-black, BrV = brown-violet, DG = dark grey, G = grey, GB = grey-black, LG = light grey, RBr = red-brown, W = white.

taxonomical units. The features are following: exoskeleton length; the face width in the apical part, in the middle and in the apertural part of the conulariid exoskeleton; apical angle in the apical part, in the middle and in the apertural part of the conulariid exoskeleton; relations of faces width and apical angles in various parts of exoskeleton; the width/ depth relation (height) of a midline; the width/depth (height) relation of a corner groove; the number of transversal rods per 10 mm; the number of longitudal rods per 10 mm; the number of ribs per 10 mm and their shape.

The most important characteristics related to the exoskeleton represent: a presence of apex, its shape, a presence of aperture, the number of lappets, a deformation of the exoskeleton surface, a spatial exoskeletal deformation, pathological features.

REMARKS TO THE CHARACTERISTICS

The most usual mode of preservation are fragments of conulariid exoskeletons. Nevertheless, these fragments are sometimes the only evidence of presence of conulariids in a fossil record. The determination of the species can be complicated by unpresence of all important characteristics on the exoskeleton.

Pathological features were observed on 11 specimens. All pathologies display as irregularities of a sculpture or as

Tab. 3. Biometric characteristics.

TAXON	L (range/ usual value)	Wa (range/ (usual value)	W (range/ usual value)	Wap (range/ usual value)	midline (% of samples)	W/H midline (average)	corner groove (% of samples)	W/H corner groove (average)	secondary midline (% of samples)	apical angle (range, in °)	Internal structures
Genus *Conularia* Miller, 1818											
Conularia rugulosa	13–43 (25)	1–5 (3)	3–8 (7)	4–11 (8)	26	1,65	18	1,90	0	11–17 (12)	0
Subgenus *Archaeoconularia* Bouček, 1939											
Conularia (Archaeoconularia) fecunda	13–63 (29)	3–36 (7)	4–44 (7)	4–38 (8)	95	1,67	97	2,65	3	2–28 (14)	0
Conularia (Archaeoconularia) insignis	8–95 (25)	3–16 (9)	2–82 (15)	4–32 (20)	53	2,35	39	3,11	0	8–36 (10)	0
***Subgenus Mesoconularia* Bouček, 1939**											
Conularia (Mesoconularia) fragilis	13–58 (35)	7–12 (8)	16–19 (18)		14	1,00	85	6,21	0	7–19 (12)	0
Subgenus Plectoconularia Bouček, 1939											
Conularia (Plectoconularia) hanusi	13–20 (16)	1–4 (4)	3–8 (5)	4–6 (6)	100	1,33	67	1,00	0	3–6 (5)	0
Conularia (Plectoconularia) proteica	7–38 (13)	1–4 (2)	3–12 (8)	4–10 (7)	13	1,50	46	1,71	0	5–13 (11)	0
Genus Exoconularia Sinclair, 1952											
Exoconularia consobrina	13–120 (65)	4–34 (10)	7–40 (29)	13–42 (15)	59	2,87	36	3,19	0	7–29 (19)	0
Exoconularia exquisita	6–110 (24)	4–34 (15)	7–40 (29)	13–42 (15)	32	3,22	60	1,99	0	7–22 (8)	0
Genus *Metaconularia* Foerste, 1928											
Metaconularia anomala	9–86 (30)	0,9–19 (12)	1,8–26 (15)	2,3–12 (13)	40	2,26	11	2,44	0	6–22 (12)	0
Metaconularia imperialis	3–135 (38)	2–17 (10)	4–61 (15)	4–37 (33)	51	3,76	67	3,47	0	10–25 (20)	0
Metaconularia kettneri	10–48 (24)	□	6–21 (7)	□	80	1,63	100	3,1	0	8–22 (14)	0
Genus *Pseudoconularia* Bouček, 1939											
Pseudoconularia grandissima	24–123 (86)	4–14 (8)	12–70 (22)	22–105 (36)	29	4,43	14	4,5	0	12–24 (17)	0

Legend: L = lenght of exoskeleton, Wa = width of face in the apertural part of the exoskeleton, W = width of face in the middle part of the exoskeleton, Wap = width of face in the apertural part of exoskeleton, all dimension in milimetres; W/H = width/hight (depth) of the midline or corner groove. □ – the preservation of the specimens does not allow to measure these characteristics.

disfigurations of exoskeletons. Three main types of pathologies according to Babcock *et al.* (1987) were recognised: scalloped injuries, cleft injuries, embayed injuries.

Scalloped injuries represent changes of regularity of the sculpture. They are indentified as an angular unconformity between normal and truncated rod. It means minimally breakage of the exoskeleton. Scalloped injuries are usually observed at the apertural area and in the frame of one face. *Cleft injuries* represent V-shaped /triangle profile/ incisions into the conulariid exoskeleton. Damaged material was supplied by the secretion of integument. This type of pathologies can be mostly identified along the corner grooves and hit both of the adjancent faces. *Embayed breakage patterns* involve the truncation of many rods /10–20/ at any place of the exoskeleton. Healing area differs from the regular sculpture by its lack of rods and incremental rings of tissue repair.

Measurements of midlines and corner grooves and numbers of transversal and longitudal rods indicate similarities in individual genera and subgenera which corroborate present systematic clasification of the conulariids from the Lower Palaeozoic of the Prague Basin (see Tabs. 3 and 4).

Tab. 4. Biometric characteristics.

TAXON	transversal rods (% of samples)	number of transversal rods per 10 mm	longitudal rods (% of samples)	number of longitudal rods per 10 mm	course of transversal rods	number of ribs per 10 mm	shape of ribs	deformation of exoskeleton surface (% of samples)	spatial deformation of exoskeleton (% of samples)	Pathologies (% of samples)
Genus *Conularia* Miller, 1818										
Conularia rugulosa	100	20	0	0	G	0	0	0	0	0
Subgenus *Archaeoconularia* Bouček, 1939										
Conularia (Archaeoconularia) fecunda	67	50–250 (150)	5	0	S	0	C	38	11	6
Conularia (Archaeoconularia) insignis	47	50–200 (60)	4	60–120 (80)	S, A	50–180 (80)	O, Ck C	65	1	1
***Subgenus Mesoconularia* Bouček, 1939**										
Conularia (Mesoconularia) fragilis	100	10–40 (30)	0	0	A	30–60 (50)	C, O	100	0	0
Subgenus Plectoconularia Bouček, 1939										
Conularia (Plectoconularia) hanusi	100	120–300 (140)	0	0	S	300–400 (350)	O	100	0	0
Conularia (Plectoconularia) proteica	100	20–60 (40)	0	0	G, A S	70–150 (100)	J	46	0	0
Genus Exoconularia Sinclair, 1952										
Exoconularia consobrina	67	20–150 (40)	24	20–110 (70)	S	20–70 (60)	O, C	43	0	0
Exoconularia exquisita	86	20–90 (60)	52	20–80 (40)	S, A	10–90 (40)	O, C S, T	53	10	2
Genus *Metaconularia* Foerste, 1928										
Metaconularia anomala	5	30–80 (30)	3	40	S	0	0	5	56	0
Metaconularia imperialis	100	15–100 (30)	69	15–100 (30)	S, A	20–100 (30)	C, S, O	54	0	2
Metaconularia kettneri	40	30–50 (40)	20	30–50 (30)	A	30–50 (30)	C	0	0	0
Genus *Pseudoconularia* Bouček, 1939										
Pseudoconularia grandissima	48	10–30 (20)	100	20–90 (40)	S	20–40	T, J	57	0	0

Legend: course of transversal rods: A – arched, G – "gothic" arched, S – straight; shape of ribs: C – circle, Ck – cask, J – jumb, O – oval, S – square, T – triangle.

The most often it is possible to evaluate face width in the middle part of the exoskeleton because of the fact that the apical or apertural parts of the exoskeleton are preserved very rarely.

CONCLUSIONS

Main conclusions which have been inferred from the data presented in tables are following.

The most usual mode of conulariid preservation is exoskeleton with four faces. On the other hand, the cross section is not preserved in majority of samples. Spatial deformation of the most of specimens caused more or less important changes of the original shape of the exoskeleton. Deformations could be caused by currents in life of conulariids or by pressure of underlying beds during fossilization.

Strictly biometric data show wide range of measurements. Maximal variability of exoskeletal length and face width was observed at species *Conularia (Archaeoconularia) insignis* Barrande, 1867 and *Metaconularia imperialis* Barrande, 1867. These species have the stratigraphical range through the Ordovician and it seems they were very succesful. There were probably several ecological forms within the mentioned species because fossils can be found in various facies (shales, iron ores, sandstones) of the Ordovician of the Prague Basin.

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PALAEOALGOLOGY AND PALYNOLOGY OF THE VACENOVICE LAKE

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Organic sediments have been found in the Hodonín area (some 10 km N of Hodonín, S Moravia) during Quaternary-geological survey conducted by the Czech Geological Survey in Prague (P. Havlíček). From botanical, ecological and geological viewpoints, these sediments are represented by fen bogs in forested area of wind-blown sands of the so-called Moravian Sahara (Doubrava). Depressions between dunes of wind-blown sand are either filled by organic sediments or expose impermeable Neogene clayey silty sands or white fine-grained sands. The interpretation of palynological data was also based on the study of lakes which persisted till these days and on other palynological knowledge.

A detailed palynological and paleoalgological study of organic sediments was motivated by sampling of these sediments at the Vacenovice locality (a shallow depression at the locality, thickness 0.5 m). By virtue of favourable circumstances, this locality was scheduled for protection and proclaimed the Jezero Natural Monument. Recent botanical research was conducted by P. Lustyk (Agency for Nature and Landscape Protection CR Brno) in this area within the Treatment Plan for 1999–2003.

Original lakes are rare on most of the area of the Czech Republic which was never glaciated. As indicated by new palynological research, this supposition does not fully apply to southern Moravia. The ongoing palynological research at various localities (see map – Fig. 1) shows that lakes were present at a number of them in the far past – the Čejč Lake, the Kobylí Lake, Vacenovice-Jezero and Vlkoš. The latter two localities lie south of the former Vracov Lake, but the succession of their deposits does not cover the whole of the Holocene: it shows prominent hiatuses with discontinuous succession of stratigraphically determinable strata.

The locality of Vacenovice-Jezero, covering an area of 92,431 m^2, lies NNE of the village of Vacenovice, N of Hodonín, southern Moravia. Approx. 0.5 m of sediments were acquired by a hand-drill for the purpose of pollen analysis. Thirteen samples were taken and one sample (VAC 1/0.36-0.40 m) was radiometrically dated using ^{14}C method (Laboratorium C-14 Instytutu Fizyki Politechniki Slaskiej w Gliwicach Poland; Gd-17036, age 2900±130 years B.P.). The samples were processed in a laboratory using a standard set of methods for sporomorph separation by maceration and adapted Erdtman acetolysis. The obtained solution of sporomorphs was kept in a mixture of glycerine – ethanol – distilled water at suitable ratio. Microscopic study resulted in the pollen diagram and palaeoalgological diagram.

Stratigraphic determination follows the classic Firbas' classification of the development of central European vegetation used for the evaluation of palynological spectra in the Czech territory. The determination of palynomorphs was based on permanent preparations of Recent pollen grains and spores and on the available determination keys. Classification of algal flora was evaluated in accordance with the current studies of Jankovská and Komárek and further photographic annexes.

Sampling for the pollen analysis and palaeoalgological study respected the courses of the individual strata:

- 0.00–0.38 m – organic sediment: sedge fen (various degree of degradation), with clay admixture and macroflora
- 0.95 m – bluish green-grey redeposited sand to steel-grey silt with strong clay component from 0.95 m
- steel-grey fine-grained sand, age Tertiary – Pannonian.

Upper part of the section, now buried by earth:

- 0.00–0.36 m – sediments of the Subatlantic IX, Xa, Xb (2800/2300 years B.P.– Recent)
- almost all sediments of the Preboreal to Subboreal IV–VIII (10250–2800/2300 years B.P.) are not preserved
- 0.36–0.40 m – radiometric age determined by ^{14}C method: 2900±130 years B.P. (Gd 17036 – Gliwice Poland)

Lower part of the section represents a lake (remains of lacustrine sediments)

- 0.40–0.50 m – Late Glacial I–III (15000/13000–10250 years B.P.).

Palynological and palaeoalgological analysis revealed that a lake really existed at the given locality in the Late Glacial, as also evidenced by maps. Development of the locality was characterized by the deposition of organic sediment (sedge fen) in the Holocene. The preserved sediments include stratigraphically well dated interval from the early Holocene (Preboreal, IV, 10250–9100 years B.P.) followed by a hiatus till the end of the Subboreal (VIII, 5100–2800/2300 years B.P.). Fen of the Early Subatlantic (IX, 2800/2300 years B.P.–500/650/700 A.D.) and Late Subatlantic (Xa, 500/650/700–1200 A.D.; Xb, 1200 A.D.–present) could be relatively easily dated using palynological and stratigraphic methods.

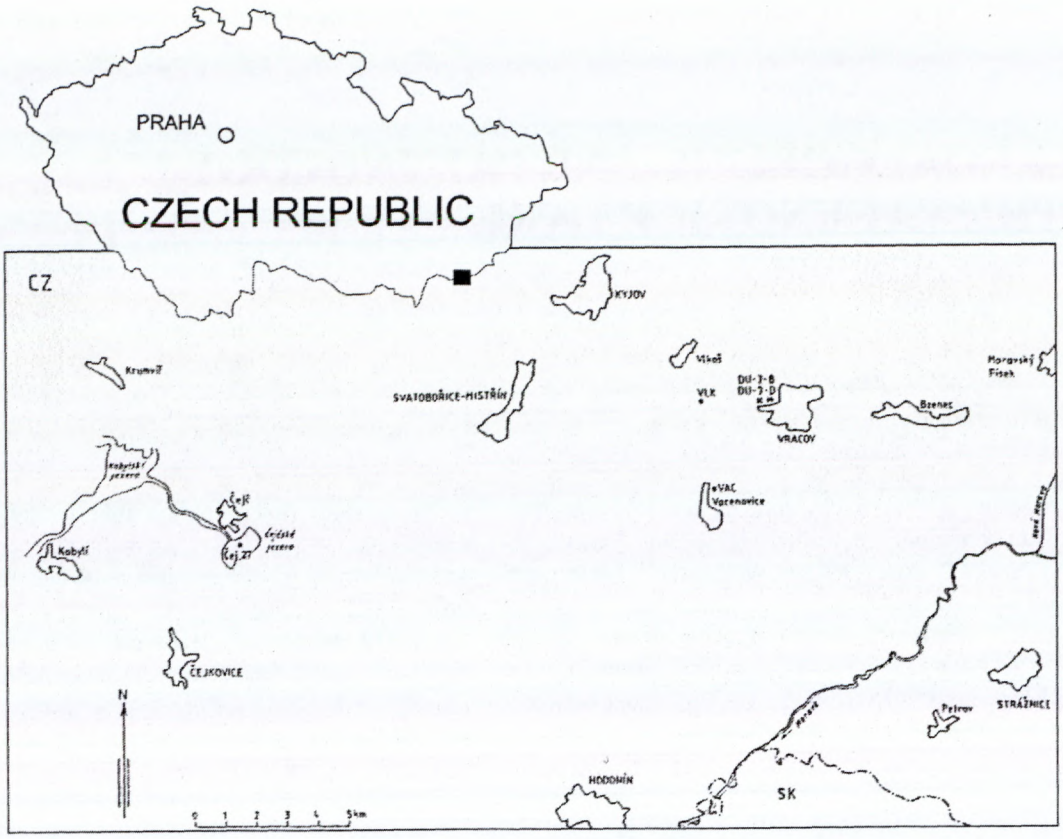


Fig. 1. A map of sediments of former lakes subjected to palynological study, southern Moravia.
(Břízová: VAC – Vacenovice-Jezero locality, VLK – Vlkoš locality, Čej27 – a borehole in sediments of the Čejč Lake; Rybníček, Rybníčková and Svobodová: DU-7-B, DU-7-D – Vracov Lake).

The Late Glacial (I–III): vegetation in the ambience of the lake corresponded to a poor mineral substrate and immature soils then originating (*Juniperus*, *Salix*, *Hippophaë rhamnoides*, *Ephedra*). These isolated woodlands of pine-birch parking character with heliophytic non- arborescent vegetation with *Helianthemum*, family *Caryophyllaceae* and a presence of other Late Glacial elements such as *Armeria*, *Pleurospermum austriacum*, also with abundant marsh-type vegetation with family *Cyperaceae*, *Sparganium/Typha angustifolia*, *Comarum*, *Thalictrum*, and vegetation of other types with families *Apiaceae*, *Rubiaceae*, *Brassicaceae*, *Chenopodiaceae*, *Rumex*, abundant *Artemisia*, and plentiful green coccal algae directly in the lake basin.

The lake was not existing already in the Early Subatlantic IX (2800/2300 years B.P.–500/650/700 A.D.), being gradually overgrown (*Phragmites*-typ, *Sparganium/Typha angustifolia*, *Typha latifolia*). A small water body is still documented by the presence of a green alga of the genus *Botryococcus* and occasional finds of the genus *Nuphar*. Some of the documented arborescent plants are characteristic for the period of Early Subatlantic already, such as *Fagus*, *Abies, Carpinus*. In the following period of the Late Subatlantic Xa, Xb (500/650/700–1200 A.D.; 1200–present), man becomes to gain an increasing influence on the landscape (*Cannabis/Humulus*, *Vitis*, *Centaurea cyanus*). Extensive grain cultivation (*Cerealia*) and pasturing (*Juniperus*, *Urtica*, *Rumex*) on fallow land typical for the Early Subatlantic gradually turn into intensive in the late phase of the Late Subatlantic (Xb, 1200 A.D.– present). Representants of the family *Polypodiaceae* were the most common among sporophytes.

The community of algae dominated the small lake in the Late Glacial (15000/13000–10250 years B.P.). Altogether 12 types of the genus *Pediastrum* were recognized; in the order of importance, these included *P. boryanum* var. *longicorne*, *P. integrum* a *P. kawraiskyi*, and less important types *Pediastrum* sp. (not specified), *P. boryanum* (not specified in more detail), *P. boryanum* var. *boryanum*, *P. boryanum* var. *cornutum*, *P. angulosum*, *P. angulosum* var. *asperum*, *P. angulosum* var. *angulosum*, *P. simplex*, *P. simplex* var. *echinulatum*. Another important taxon among green algae was the genus *Botryococcus* (perhaps *B. pila*), with considerably smaller occurrences of other algae *Tetraedron minimum* and *Scenedesmus*.

This combination of algae, reported from the Late Glacial and Early Holocene (e.g., from Velanská cesta in the Třeboň area), is characteristic for clear water not only in small dystrophic lakes but also peat bogs. In Recent samples, these green algae have been found only at higher altitudes.

Indication value of fossil finds of algal community *P. boryanum* var. *longicorne – P. integrum – Botryococcus (pila)* characterizes cold periods after the end of the last glacial period. This dominant algal community is indicative of small water reservoirs with cold dystrophic but clear water, which is supported by the conspicuous but rare occurrence of *P. kawraiskyi*.

The locality now represents a complex of moist to wet grasslands, reed and tall sedge growths, a shallow water reservoir and willow-poplar wood with varied undergrowth of non-arborescent plants.

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COMPLETE, EARLY HOLASPID SPECIMEN OF *METASCUTELLUM PUSTULATUM* (TRILOBITA) FROM THE DVORCE-PROKOP LIMESTONE (LOWER DEVONIAN)

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Abstract: This paper provides description of a complete juvenile (early holaspid) specimen of *Metascutellum pustulatum* aff. *multiverrucatum* (Šnajdr 1960) from the locality Praha-Konvářka. This specimen allows completing the description of this species. Taxonomic value of the individual characters is discussed as well as the systematic assignment of the species.

INTRODUCTION

The specimen studied was found in weakly weathered decalcified portions of the lower part of the Dvorce-Prokop Limestone (*Nowakia acuaria* Biozone) developed in the hangingwall of the Slivenec Limestone exposed in a roadcut at Praha-Konvářka (Barrandian area, SW part of Praha, N. part of Central Barrandian Synklinorium), ca. 50 m north of a railway viaduct. The find of this specimen was listed by Budil (1992) along with other abundant and very well preserved fauna coming from this locality. The faunal assemblage is dominated by benthic elements (trilobites, brachiopods), however, the proportion of planktonic, nektonic or possibly also epiplanktonic forms is significant, too (dacryoconarid tentaculites, nautiloids, some small brachiopods). Similar conclusions were adopted by Vaněk (1961) who also studied this locality. New list of trilobite and brachiopod fauna from this locality was published also by Havlíček and Vaněk (1998). Fine-grained biodetrital accumulations are locally abundant in the platy, largely biomicritic limestones, and indicate local transportation of organic remains (bioturbations, currents, wave activity ?). Signs of possibly current-induced size sorting of minute calcareous sponge spicules were reported by Kučera (1993) from this locality. However, finds of almost complete trilobite exoskeletons are also relatively frequent, including the specimen described herein.

The paper follows the modified morphological terminology used by Šnajdr (1960, 1990). The specimen described herein is deposited in palaeontological collections of the National Museum, Prague.

SYSTEMATIC PALAEONTOLOGY

Family: *Styginidae* Vogdes 1890
Genus: *Metascutellum* Šnajdr 1960

Metascutellum pustulatum aff. *multiverrucatum* (Šnajdr 1960)
Figs. 1, 2.

1992 *Metascutellum* sp. n.; Budil, p. 252

Material: Almost complete, partly disarticulated, early holaspid specimen (part of positive, negative counterpart, NM L 30 480) preserved in decalcified limestone, plus several fragments of cranidia and pygidia.

Description: Cephalon semicircular in outline, arched transversally as well as longitudinally. Glabella sharply morphologically subdivided. Axial furrows deep, particularly between eye ridges and posterior margin of cranidium. Frontal margin of glabella defined by narrow preglabellar depression. Glabella relatively narrow posteriorly, significantly widening anteriorly. Prominent widening of glabella, which occurs at S1+2 furrows, causes marked abaxial convexity of lateral circumglabellar furrows in this area. S3 small and oval, S1+2 deeply incised with a prominent median node. Anterior section shallow, markedly deepening in lateral and posterior sections S1+2. Basal impressions indistinct.

Occipital furrow and occipital ring not very well preserved on the studied specimen.

Fixigena is narrow anteriorly, gradually widening posteriorly. Central part broadly arched, transversally widened at palpebral lobe. Palpebral lobes, eye and eye ridge are imperfectly preserved, however, eyes seem to be larger and lying more anteriorly than in *Metascutellum pustulatum pustulatum* (Barrande). Anterior angle of palpebral lobe and eye probably near (tr.) L2+L3. Posterior parts of fixigenae are not well preserved in the studied specimen, however, they seem to be reduced to form short winglike projections.

The course of facial sutures is well visible only in the anterior part of the cephalon. Anterior sections of facial sutures are subparallel, like in subspecies *Metascutellum pustulatum pustulatum* (Barrande). The eyes, however, appear to be larger than those of this subspecies (Fig. 1).

Librigenae relatively broad, flat anteriorly, more arched towards the eye posteriorly. Anterior margin semicircular in

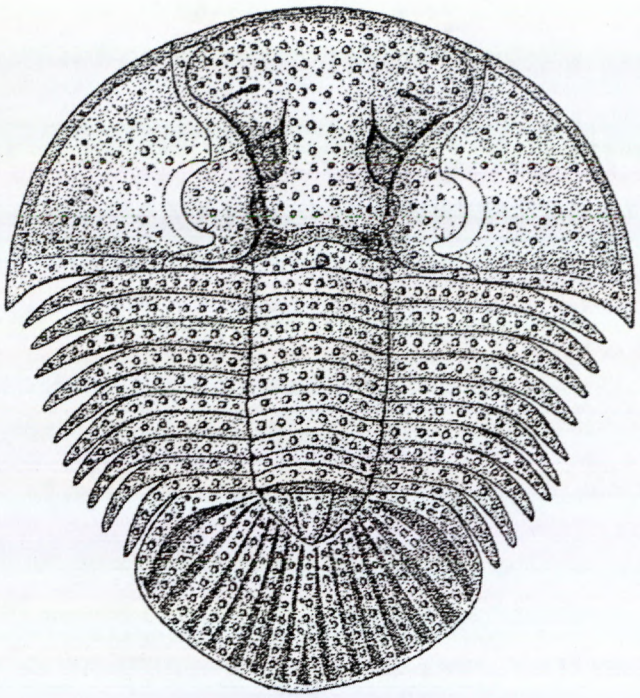


Fig. 1. ***Metascutellum pustulatum*** **aff.** ***multiverrucatum*** **(Šnajdr). Reconstruction of an early holaspid individual. After NM L 30 480. Occipital lobe and posterior part of fixigenae are reconstructed on the basis of adult specimens of** ***Metascutellum pustulatum*** **cf.** ***multiverrucatum*** **(Šnajdr) deposited in the collections of the Czech Geological Survey. With respect to the preservation of the specimen NM L 30 480, the shape and size of eyes could be only estimated.**



Fig. 2. ***Metascutellum pustulatum*** **aff.** ***multiverrucatum*** **(Šnajdr). Early holaspid individual, Dvorce-Prokop Limestone, Lower Devonian (Pragian Stage), Praha-Konvářka, NM L 30 480.**

outline. Genal angles narrow, projected into a short, blunt spine.

Rostral plate and hypostoma unknown. Librigenal doublure broad, arched (following the course of dorsal part of exoskeleton), ornamented with prominent asymmetrical ribs (terrace lines).

Thorax composed of ten segments. Axis arched, relatively broad, separated from lateral pleural lobes by prominent axial furrows. Thorax markedly narrowing posteriorly with ends of pleurae bent more sharply backwards. Doublures of pleural ends strongly arched, getting flatter towards (tr.) axis.

Pygidium subpentagonal in dorsal view, relatively small, strongly arched in longitudinal and transverse sections, somewhat concave distally. Axis subtriangular, strongly arched, only slightly trilobate, morphologically well defined. Central axial lobe slightly narrowing posteriorly.

Seven paired ribs on each lateral pygidial lobe are slightly depressed in transverse section, very gently broadening distally at posterior margin of pygidium. Inter-rib furrows narrow, flat, well defined, their width occupies 2/3 the width equals of ribs.

Median unpaired rib only slightly broader than paired ribs, divided into two bands (of approx. the same width as paired ribs) as far as after ca. 4/5 of its course. Median interpleural furrow not very distinct, narrower than paired inter-rib furrows. Width of pygidial doublure is not visible.

Sculptation: Sculptation in the studied specimen consists of two types:

1) Very dense and fine granulation, visible under strong magnification only, covers entire exoskeleton surface, including furrows. The size of these granules is approx. several hundredths of millimetre. As oppose to Šnajdr's (1960) description of *Metascutellum pustulatum multiverrucatum*, this fine granulation is well visible also in inter-rib furrows of the central part of pygidium. Also the librigenal doublure and the thoracic segments doublures are covered by very fine, dense granulation. In addition, the librigenal doublure shows fine but prominent asymmetrical ribs (terrace lines).

2) Large, thorn-like and/or rounded granules visible by a naked eye are sparsely dispersed accross the genae, glabella, dorsal parts of thoracic segments, thoracic rhachis, pygidial axis and pygidial ribs. Apart from the Šnajdr's (1960, 1986) descriptions of *Metascutellum pustulatum multiverrucatum* (Šnajdr), these large granules have not been observed at the posterior pygidial border. They are neither visible in the distal parts of interpleural furrows. The size of these granules attains several tenths of millimetre. The granules are of approximately equal size on the cephalon. On the pygidium, their size decreases somewhat smaller in the direction from the axis towards the posterior margin of pygidium, like in the *Metascutellum pustulatum multiverrucatum* (Šnajdr).

Size: The length of an almost complete exoskeleton (sag.) is ca. 7.82 mm, maximum width (tr.) is 7.2 mm.

Discussion: The studied sample resembles *Metascutellum pustulatum multiverrucatum* (Šnajdr) in some features, particularly in the width of the interpleural furrows, very narrow preglabellar depression and also in the character of cranidial sculptation. Nevertheless, I prefer to keep the nomenclature open yet as the individual is of early holaspid

age. In such individuals, it cannot be excluded that some of the characters may be still juvenile in their nature, particularly the length/width ratio and the shape of pygidium, arching of cephalon, sculptation, shape of terminal parts of thoracic segments etc. (cf. Kácha and Šarič 1991). In addition, an occurrence of *Metascutellum pustulatum multiverrucatum* (Šnajdr) was not mentioned by Havlíček and Vaněk (1998) in the faunal list from the locality and in their Odontochile-Prokopia Biofacies either. On the contrary, this subspecies is typical for the Crinoid-dominated Biofacies (similar discussion of the biofacies dependence in the subspecies of *Metascutellum pustulatum* see also Šnajdr, 1986). A rare occurrence of closely related *Metascutellum pustulatum chinon* Šnajdr has been documented (Havlíček and Vaněk 1998) in the close neighborhood of the studied locality, but in the Slivenec Limestone.

Further, from *Metascutellum pustulatum multiverrucatum* (Šnajdr), the studied sample differs in some characters of the pygidium. The median rib is only slightly broader than the paired ribs. Neither the large, sparsely dispersed granules are developed on the posterior margin of pygidium pygidial border. The sculptation on unpaired rib consists of dense and unequal sparsely distributed granulation. Many characters of the studied specimen are also shared by type subspecies *Metascutellum pustulatum pustulatum* (Barrande). These include primarily the overall morphology of cranidium and pygidium. However, the size of eyes seems to be different: eyes are somewhat larger in the studied specimen, extending with their anterior corners to L2+3. Articulation edges of the pygidium are also somewhat longer, reaching almost 1/2 the length of the pygidial anterior margin. Interpleural furrows are markedly wider at the studied specimen than in the *Metascutellum pustulatum pustulatum* (Barrande). External parts of the anterior margin of pygidium are somewhat steeper posteriorly in the studied specimen than both in *Metascutellum pustulatum pustulatum* (Barrande) and *Metascutellum pustulatum multiverrucatum* (Šnajdr). From *Metascutellum pustulatum chinon* Šnajdr and especially *Metascutellum pustulatum elitryan* Šnajdr, our specimen differs primarily in its much shorter interpleural furrow in the unpaired rib, not reaching even 1/3 the length of the unpaired rib (comparable with the pygidium of *Metascutellum pustulatum setosum* (Přibyl), figured by Šnajdr (1986) at the Pl. I., fig. 3.). From *Metascutellum pustulatum setosum* (Přibyl), the studied specimen differs in its distinctly sparser granulation and longer (trans.) S3, which are closer to axial furrows, than in *Metascutellum pustulatum multiverrucatum* (Šnajdr). The above given differences are, in my opinion, not sufficient (especially with respect to the early ontogenetic stage of the specimen) for erecting a new subspecies. Of the same reason, I also respect the classification of species *Metascutellum pustulatum* (Barrande) proposed by Šnajdr (1986) sensu Vaněk and Valíček (2002). The complete sample described by Levi-Setti (1993) on p. 303 as *Scutellum pustulatum* (Barrande) from Devonian of Morocco probably belongs to different species.

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BEDDED CHERTS OF THE PŘÍDOLÍ FORMATION (SILURIAN) AT LIŠČÍ LOM QUARRY – GAISLER GALLERY AND ČÍŽOVEC QUARRY (BARRANDIAN AREA, CZECH REPUBLIC)

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Abstract: The bedded cherts on the localities Liščí lom quarry – Gaisler gallery and Čížovec quarry had not been studied before. The content of bioclasts was studied. The succession of the diagenetical changes of the rocks, inclusive of the silicification and dolomitization, was established.

INTRODUCTION

Studied sections are situated in the Barrandian area in the core of the Amerika anticline. The locality is the "Liščí lom" quarry (Liščárna), which is situated 2 km NW from the Karlštejn castle. The Čížovec quarry is positioned NE from "Liščí lom" quarry at SE margin of the Trněný Újezd village (Fig.1).

Chlupáč and Horný (unpublished) studied the Liščí lom quarry – Gaisler gallery in the Amerika quarries area near Mořina. Sections of the Silurian Kopanina Formation (Ludlow Series), Přídolí Formation (Přídolí Series), and the Devonian Lochkov Formation (Lochkovian Stage) are well exposed at both localities. All these formations consist of carbonate sequences with common cherts, especially developed in the Přídolí Formation (Pl. 1, fig. 1). Similar rocks are exposed in the "Čížovec lom" quarry, which was not studied in detail up to now. The core of the Amerika anticline is formed by limestones of Přídolí and Lochkovian age.

The cherts are relatively rare in the Přídolí Formation. These cherts are nodular and bedded, which were studied during this research. Some special structures in limestones and dolomites and also in cherts were investigated by Mikuláš and Horný (pers. communication), who ascribed them to ichnofossils.

Silicification of limestones in the Barrandian area was studied and discussed particularly by Petránek (1951a-c), Náprstek (1954), Kukal (e. g. 1955, 1964), Svoboda *et al.* (1957), etc.

CARBONATES OF STUDIED SECTIONS

The sections at both localities are characterized by alternating platy micritic and fine and coarse-grained bioclastic limestones and fine-grained dolomites. Transitional lithofacies are present, too. Limestones contain fine-grained bioclasts, especially fragments of crinoids and ostracod shells. Some bioclasts are frequently silicified and dolomitized. Crinoidal columnals are rounded. The micrite often recrystallized to sparite. Dolomites are rich in the clayey insoluble residue, or organic matter. Size of crystals ranges up to 0.2 mm being markedly idiomorph. Dolomite is of early diagenetic origin (comp. with Kukal 1964). The boundaries between dolomites and limestones are both gradual and sharp. Transitions between limestones and dolomites and between limestones and silicites were observed in thin-sections.

BEDDED CHERTS

Some samples of the studied silicites could be classified as spiculites, because of the high content of sponge spiculs (Pl. 1, fig. 4). It is probable, that also other cherts originally represent spiculites, but the spiculae were dissolved during the diagenetic processes.

Variable content of bituminous matter resulted into thin lamination of bedded cherts. Such laminae do not show sharp boundaries (Pl. 1, fig. 3). The content of bioclasts changes in general. The dark-coloured laminae contain no fragments of ostracod shells. Crystals of dolomite were observed in the dark-coloured laminae in one sample. Dolomite crystals occur only in dark-coloured laminae which were probably enriched by Mg-ions and therefore the origin of dolomite is considered as early diagenetic. Alternation of laminae is mostly regular. Occurrence of fragments of ostracod shells are limited to the light-coloured laminae only. Because of the above described features, the origin of laminae could be explained by periodical possibly seasonal changes.

Microcrystaline quartz prevails; it could be explained by crystallization of silica gel whose origin can be biogenic (Kukal 1964). Chalcedonic form of quartz could be derived from the solutions.

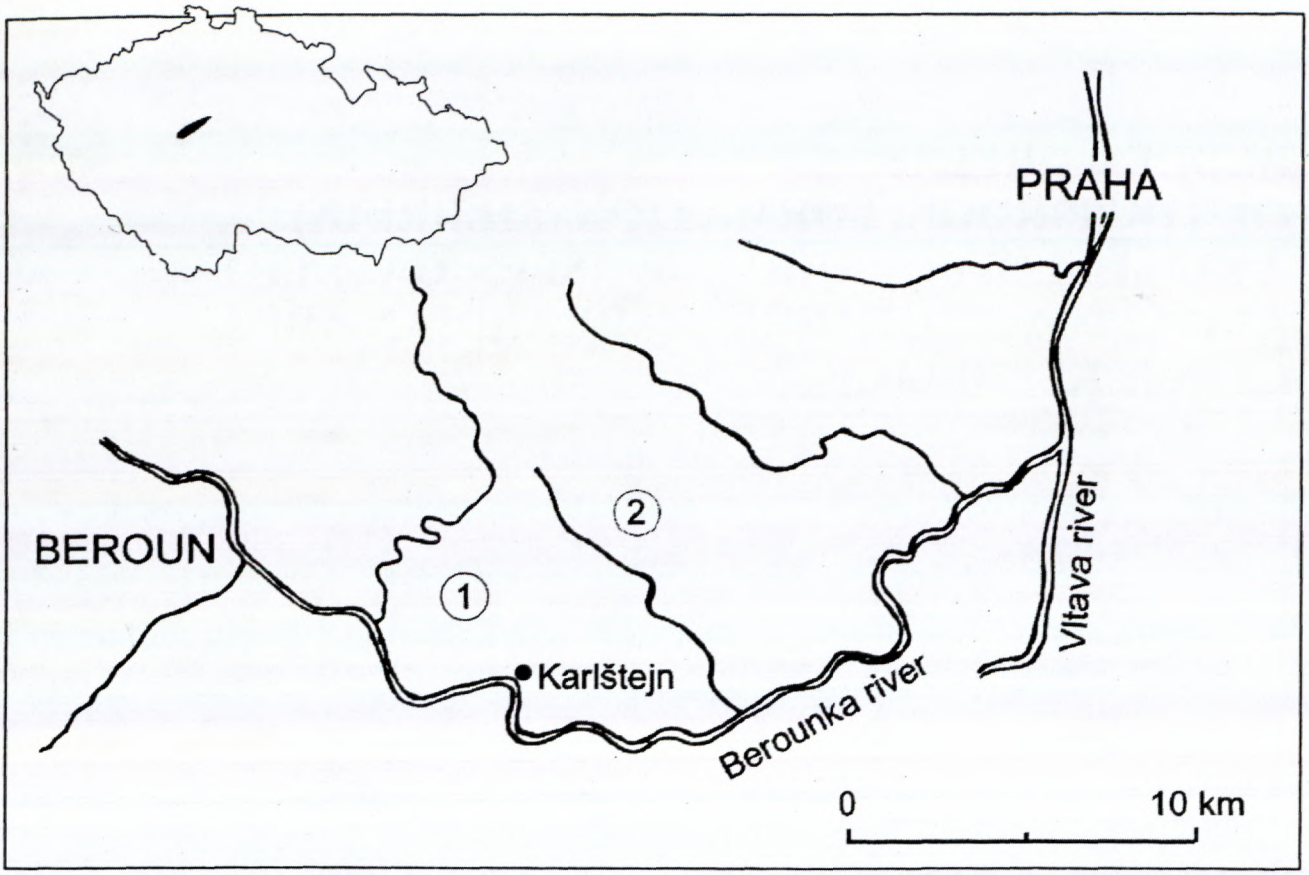


Fig. 1. The position of studied localities: 1 – "Liščí lom" quarry (Liščárna) – Gaisler gallery, 2 – Čížovec quarry.

Bioclasts are represented by sponge spicules and ostracod shells. Diameter of spicules is about 0.032 mm. The preservation of axial chanel is common and sometimes filled by pyrite. The length of spicules and ostracod shells varies around 1.0 mm. Ostracod shells occur in light-coloured laminae only being often silicified. The occurrence of radiolarians is problematic because their sphaeroidal cross-section is similar to those of sponge spicules.

One sample from the "Čížovec lom" quarry contains silicified dolomite rhombs up to 0.2 mm in diameter. Crystals are mostly idiomorphic. Quartz veins and cracks filled by calcite are common. Quartz veins are cutted by calcite veinlets. The process can be reconstructed as follows: (1) The crystallization of microcrystalline quartz and origin of quartz veins (filled by 2–3 generations, Pl. 2, fig. 1a) – (2) the cracking and filling of cracks by calcite (Pl. 2, fig. 1b) – (3) pressure solution and origin of stylolites, which cut calcite veinlets. The next stages are characterized by crystalline dolomite (4) closely associated with stylolites and secondarily silicified in some cases (5) (Pl. 2, fig. 2). The pyrite is the youngest (6), because of single crystals (size from 0.016 to 0.2 mm) are regularly distributed within the sample.

All stages of the succession are not present within the studied samples. The latest phase of crystallization of quartz veins is the crystallization of calcite in the center of veins. The origin of veins with calcite could be explained by dehydration of silica gel (Petránek 1951b). According to some authors (e.g. Suchý and Zeman 1999) the later hydrothermal processes cannot be excluded.

A very probable ichnostructure was observed in one thin-section which shows sharp contact between laminated spiculite and dolomite filling of vertical burrow. Dolomite crystals within this structure are zonal. This could be explained by a late diagenetic growth of earlier diagenetic dolomite. The spiculite laminae are bent down at the margin of this structure. Silicified thin layer at the margin of this structure is perceptible, but no spiculae are present inside. It would be the equivalent of thin slime layer, which is hardening the burrow margin.

CONCLUSIONS

The observations of cherts in the "Liščí lom" quarry and "Čížovec lom" quarry agree with the early diagenetic concept of silicification reported by Petránek (1951a-c), Náprstek (1954), Kukal (1955, 1964) and Svoboda *et al.* (1957). The late diagenetic origin of silicification, however, is also probable and supported by the above described succession of processes (under 1–6). The process of silicification and dolomitization observed in limestones of the Přídolí Formation is comparable with that of the Lochkov Formation, though some differences exist (prevalence of bedded silicites etc.)

Both possibilities of succession of dolomitization and silicification were proved already by Svoboda *et al.* (1957).

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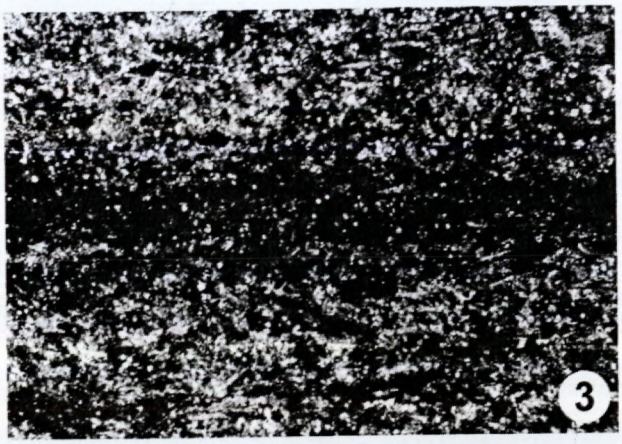
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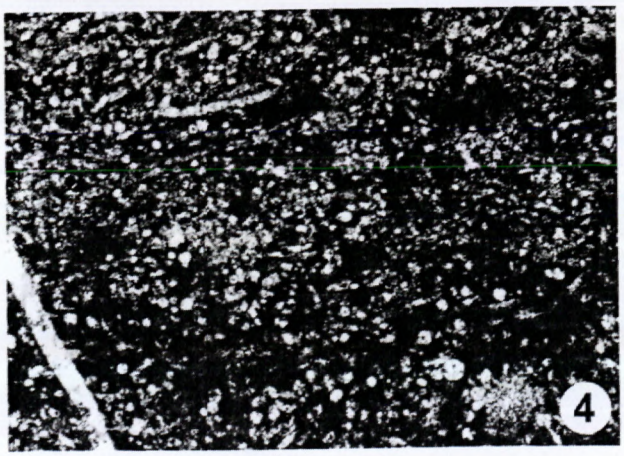


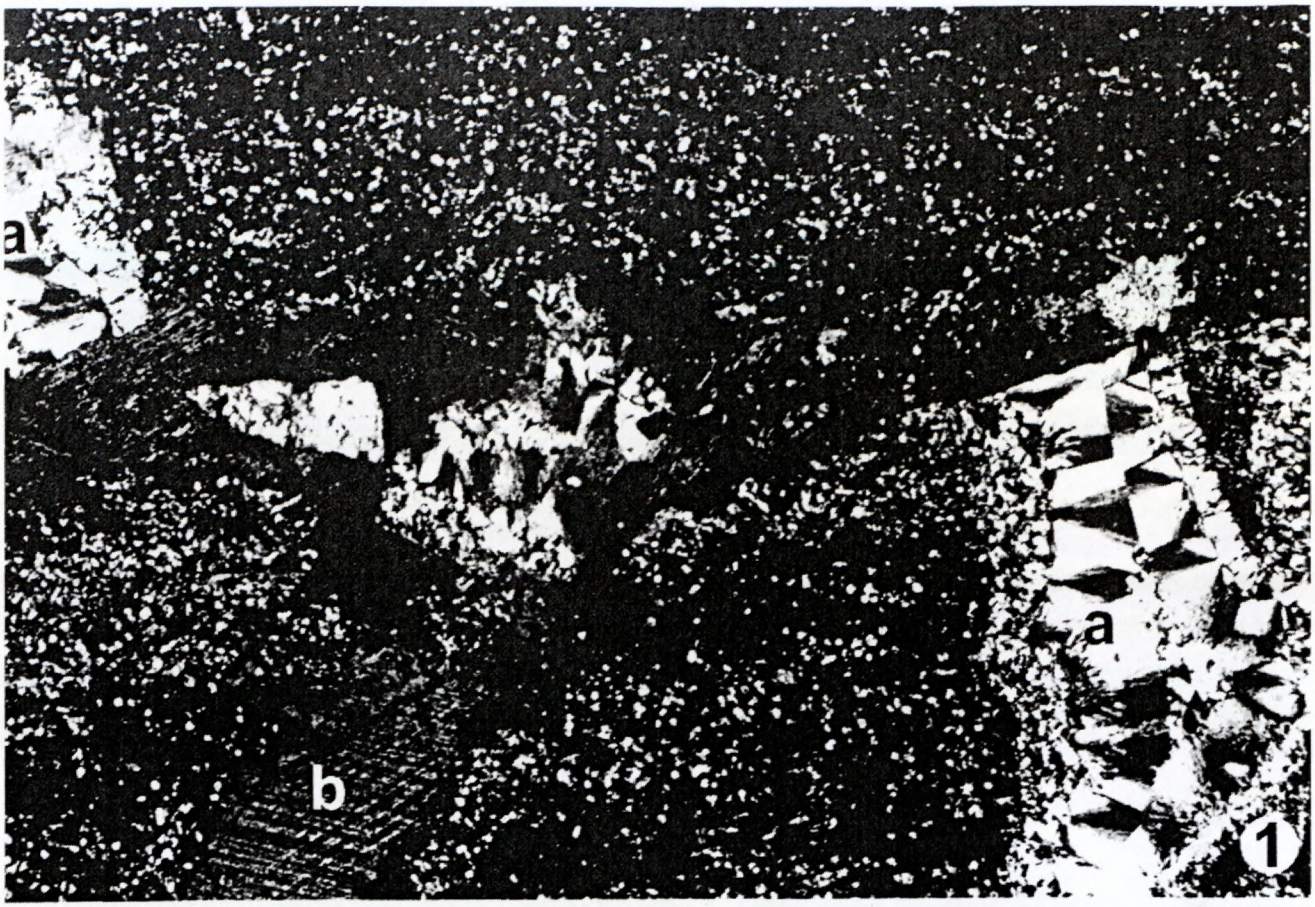
Plate 1

1 – The sequence of the middle part of Přídolí Formation in Liščí lom quarry – Gaisler gallery, which is characterized by alternating of platy limestones and dolomites and bedded cherts. Photo by I. Chlupáč.

2 – The sample of characteristic alternating of carbonate rocks and bedded cherts. Slightly enlarged. Photo by author.

3 – The example of lamination. Enlarged 31x, crossed nicols. Photo by author.

4 – The example of spiculite. Enlarged 79x, crossed nicols. Photo by author.



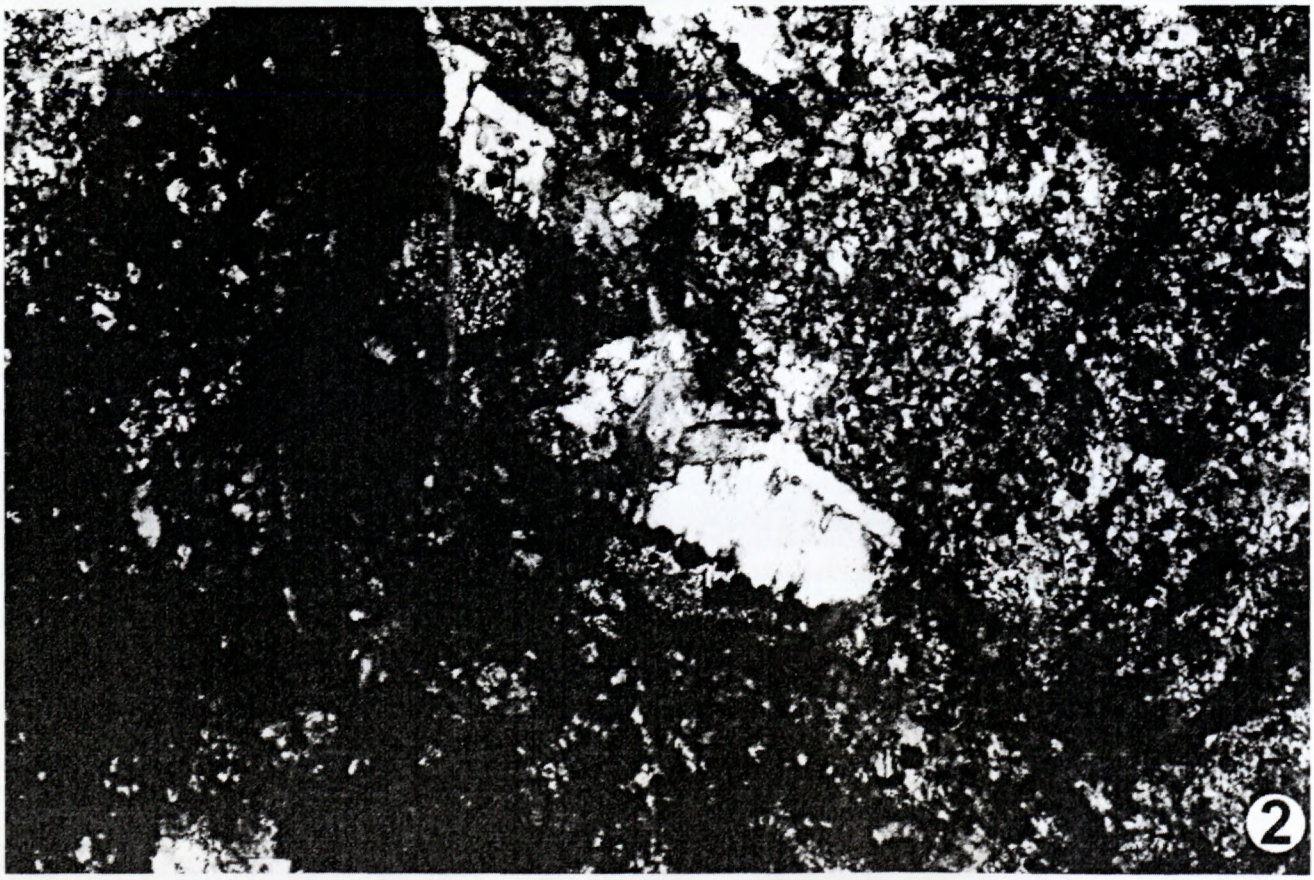


Plate 2

1 – Quartz veins (a) disordered by calcite filled cracks (b). Enlarged 31x, crossed nicols. Photo by author.

2 – The silicified dolomite rhomboeders. Enlarged 79x, crossed nicols. Photo by author.

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BIOSTRATIGRAPHY OF THE JINCE FORMATION (MIDDLE CAMBRIAN) IN THE PŘÍBRAM-JINCE BASIN: HISTORICAL REVIEW

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Abstract: All published stratigraphical concepts and subdivisions of the Middle Cambrian Jince Formation (= *"faune primordiale"* of the *"étage C"* in the primary sense of J. Barrande) of the Příbram-Jince Basin are summarized. In the second part of the paper definition and history for each of the hitherto proposed biostratigraphical units are shortly discussed. Four figures include comparison and correlation of all concepts, including graphic representation of stratigraphical ranges of taxa applied for stratigraphic subdivision. Recommended biostratigraphic subdivision of the Jince Formation for the Příbram-Jince Basin is presented.

INTRODUCTION

The Barrandian area, located in the central part of the Bohemian Massif represents an unmetamorphosed to slightly metamorphosed Proterozoic and Lower Palaeozoic (Cambrian to Devonian) sedimentary sequence with subordinate volcanic rocks (Fig. 1). The richly fossiliferous Palaeozoic rocks of the Barrandian area have been studied since the middle of the 18th century. However, the first stratigraphic division was elaborated to the end of the first half of the 19th century by J. Barrande. His concept was published in a preliminary report on the *"Système silurien"* (Barrande 1846) and it was subsequently fully explained in the first volume of the *"Système silurien du centre de la Bohême"* (Barrande 1852). In Barrande's concept the oldest fossiliferous levels, containing his *"faune primordiale"* (i.e. Middle Cambrian in the present sence), were designated as *étage C*. The Cambrian age of this fossiliferous *étage C* was recognized by Marr (1880), who, however, applied the "Cambrian" in the Sedgwick's extensive sense and thus embodied also the whole overlying *étage D* (i.e. belonging to the Ordovician). Incorporation of the underlying unfossiliferous conglomerates in the Cambrian was finaly adopted by Pošepný (1888).

The designation *"Ginetzer Schichten"* (= Jince Formation in the present sence) was proposed by Lipold and Krejčí (1860) for the *"étage C"*. The fossils of this formation were reported already in the 18th century; several trilobite species were described in the twenties of the 19th century, e.g. *Trilobites Sulzeri* – now *Conocoryphe sulzeri*. (Schlotheim, 1823) and *Trilobites hoffi* – now *Elipsocephalus hoffi* (Schlotheim, 1823), but the culmination of palaeontological research is also associated with the name of J. Barrande, who published seven volumes (in reality printed as 22 books) of his *"Système silurien du centre de la Bohême"* in the period 1852–1887. Since then, the Barrandian area occupies a special position among the classical Lower Palaeozoic regions.

Fossiliferous Cambrian rocks (by Barrande labeled originally as *"étage C"*) crop out in two separated areas in the Skryje-Týřovice area and in the larger Příbram-Jince Basin (Fig. 1). Biostratigraphy of the Jince Formation within the Příbram-Jince Basin will be discussed only.

Barrande's extensive palaeontological material from the *"étage C"* originated from several tens of fossil sites. Because he and his colaborators used cumulative designations of localities, only the following eight names are used on labels as Cambrian localities within the Příbram-Jince Basin (Chlupáč 1999): Baschtina = now Baština, Hrachowischt = now Hrachoviště, Felbabka, Reykowitz = now Rejkovice, Welka = now Velcí, Ginetz = now Jince-Vinice, Komorsko = now Písky, Zátor = now Velká Bába (Fig. 1).

HISTORICAL REVIEW

Although J. Barrande carefully recognized individual stratigraphic subdivisions within his "Système silurien" (Chlupáč 1999), neither Barrande nor the other authors proposed any biostratigraphic division for *the "étage C"* (= Middle Cambrian sediments) during the 19th century

The possibility of biostratigraphical subdivision of the Middle Cambrian was for the first time indicated by Želízko (1911, p. 2), who recognized substantial differences in fossil assemblages on the Vystrkov Hill near Jince (Fig. 1, locality 8). Actually Želízko (curator in the Museum of the Geological Survey in Vienna) distinguished and discussed five different levels, but only two of them were labeled by names – **"quartzitic greywackes with *Stromatocystites pentangularis*"** overlain by" shales with **"*Agnostus integer*"** (Fig. 2.1). However, the first true biostratigraphical scheme

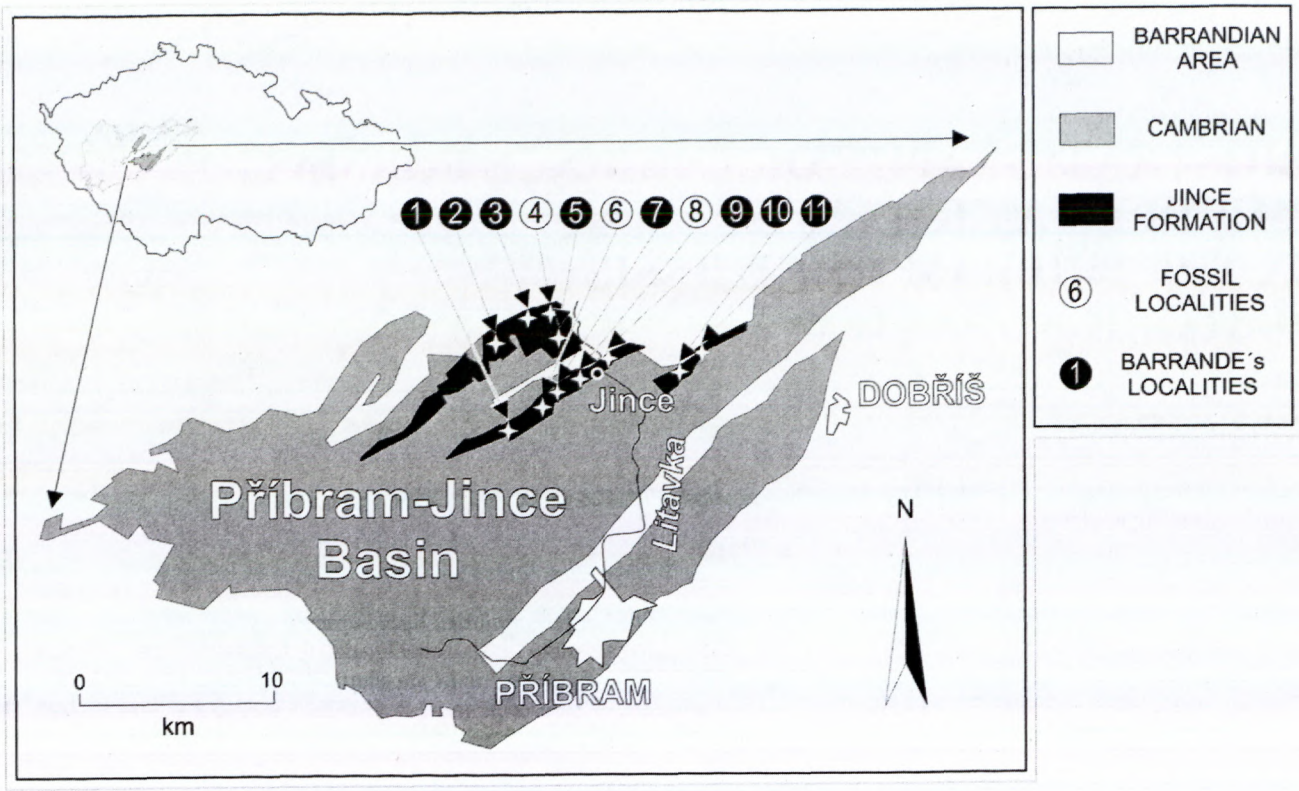


Fig. 1. Simplified sketch map showing location of most important fossiliferous localities and/or sections in the Middle Cambrian Jince Formation within the Příbram-Jince Basin. Barrande's original designations are mentioned in brackets.
1 – Baština (= Baschtina), 2 – Hrachoviště (= Hrachowischt), 3 – Felbabka, 4 – Ostrý, 5 – Rejkovice (= Reykowitz), 6 – Koníček, 7 – Velcí (= Welka), 8 – Vystrkov, 9 – Jince-Vinice (= Ginetz), 10 – Písky (= Komorsko), 11 – Velká Bába (= Zátor).

was published 15 years later by Šuf (assistant Professor at the Mining school in Příbram), who established five levels (four of them were already known to Želízko; Fig. 2.2). Šuf established **"Level *a* with *Paradoxides rugulosus*", "Level *b* with *Stromatocystites pentangularis*", "Level *c* with *Paradoxides bohemicus*", "Level *d* with *Ellipsocephalus hoffi*"** and **"Level *e* with *Lingulella Walcotti*"**; three of these levels were based on stratigraphically restricted ranges of polymeroid trilobites (*P. rugulosus*, *P. bohemicus* and *E. hoffi*), the other two were related to edrioasteroid echinoderm (*S. pentangularis*) and inarticulate brachiopod (*L. matthewi*), respectively. Kettner and Bouček (1936, Tab. III) modified the biostratigraphic subdivision of the Jince Formation in calling all units as zones and proposing some nomenclatorical changes; they distinguished the following zones: **Paradoxides rugulosus, Paradoxides spinosus and Stromatocystites pentangularis, Paradoxides bohemicus, Ellipsocephalus hoffi**, and **Lingulella walcotti** (Fig. 2.3). It is important to emphasize that Kettner and Bouček (1936) also detached the unfossiliferous lowermost levels of the Jince Formation.

Substantial changes in general understanding of the Barrandian area, including biostratigraphy of the Jince Formation, are associated with the mapping performed by the *Státní geologický Ústav Československé Republiky* (= Czech Geological Survey Prague) after the second world war. The Cambrian research was realised by Havlíček and Šnajdr between 1950 and 1970. The activities resulted into formal changes in biostratigraphic nomenclature published successively by Šnajdr (1950), Šnajdr and Havlíček (1951), and Šnajdr (1958) (Fig. 2.4–6). Ongoing palaeontological revision of trilobites evoked formal changes in designation - *Paradoxides gracilis* for the former *Paradoxides bohemicus* (proposed and justified by Prantl 1940) and published by Šnajdr (1950) and also *Eccaparadoxides pusillus* for the former *Paradoxides rugulosus* modified by Šnajdr (1958). Šnajdr (1950) substituted the earlier formal designation "level with" by zones; he also proposed to label the youngest parts of the fossiliferous sequence (e.g. "Level *d* with *E. hoffi" and "Level e* with *L. matthewi*", respectively) as the Hydrocephalus lyelli Zone (Fig. 2.4). Šnajdr and Havlíček (1951) distinguished the **"Lower Jince beds $c\beta_1$"** and **"Upper Jince beds $c\beta_2$"** within the Jince Formation. Their designation "Upper Jince beds $c\beta_2$" is identical with the earlier understanding of the Jince beds, e.g. this unit includes the fossiliferous shales, greywackes and sandstones only. The designation "Lower Jince beds $c\beta_1$" was used for the unfossiliferous sequence of sandy and quartz greywackes established between the Lower Cambrian conglomerates and the fossiliferous "Upper Jince beds $c\beta_2$" (Fig. 2.5). The biostratigraphic division was taken over by Havlíček (1961, 1963) without any change. The scheme was subsequently slightly altered by Havlíček (1971), who used the term **"Eccaparadoxides pusillus Zone, including the *Stromatocystites* Facies"**, for the lower fossiliferous part of the Jince Formation and the earlier stratigraphic subdivision for the middle and upper parts of the sequence accepted without any change (Fig. 3.1). Later Šnajdr (1975a) brought the attention to ostracodes using restricted stratigraphical ranges of three species of the genus *Konicekion* Šnajdr, 1975 for introduction of three biozones (Fig. 3.2). Šnajdr (1975b) substituted the earlier denotation Stromatocystites

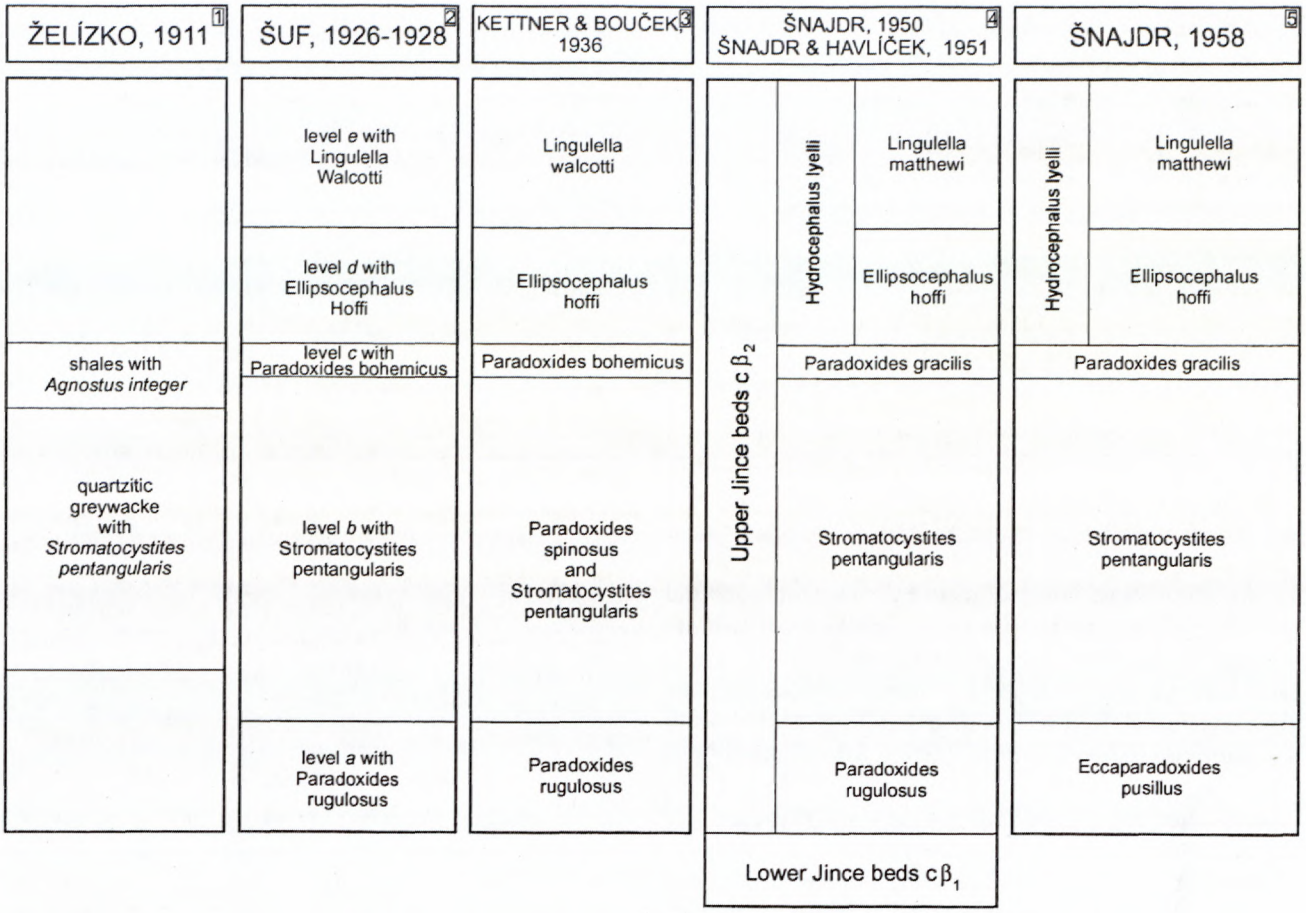


Fig. 2. Comparison of biostratigraphical subdivision of the Jince Formation proposed by: 1. Želízko (1911), 2. Šuf (1926–1928), 3. Kettner and Bouček (1936), 4. Šnajdr (1950), 5. Havlíček and Šnajdr (1951), and 6. Šnajdr (1958).

pentangularis Zone by establishment of the Hydrocephalus minor Zone, he puted the E. hoffi and L. matthewi zones together and classified the zones of E. pusillus, P. gracilis and H. lyelli as taxon-range zones for the first time (Fig. 3.2).

More recently new stratigraphical data have been provided by Fatka (1989), Mergl and Šlehoferová (1990), Fatka and Kordule (1992) and Kordule (1996), and/or reviewed by Havlíček (1998). Fatka (1989) and Fatka and Kordule (1992) introduced the **Litavkaspis rejkovicensis** and **Acadolenus snajdri** taxon-range zones as separate subzones in the lower half of the Eccaparadoxides pusillus Biozone; they have distinguished the **Ornamentaspis-Conocoryphe** (Alueva-Conocoryphe) and **Dawsonia** horizons; established the Onymagnostus hybridus Biozone and redefined the **Ellipsocephalus hoffi-Rejkocephalus** and **Rejkocephalus-Lingulella** in the sense of assemblage-zones; and finaly, proposed to call the poorly fossiliferous part of the sequence as **Interval between E. pusillus and P. gracilis** (Figs. 3.3, 4.1). Mergl and Šlehoferová (1990) distinguished seven associations based on restricted occurrences of the following inarticulate brachiopods: ***Westonia ? fatkai***, ***Botsfordia***, ***Acrothele***, ***Westonia bohemica***, ***Lindinella***, ***Lingulella havliceki***, and ***Lingulella matthewi*** (Fig. 3.4). The most complicated biostratigraphic subdivision was published recently by Kordule (1996). In his paper, the following new biostratigraphical units were proposed: **Westonia + Ellipsocephalus**, **Onymagnostus + Doryagnostus**, **Onymagnostus + Hypagnostus**, **Acanthocystites + Akadocrinus** – all in the sense of assemblage-zone; **Interzone A**, **Interzone B**; **Decacystis n. sp.** and **Lindinella kordulei** horizons (Fig. 4.3). Havlíček (1998) altered a little the biostratigraphic subdivision, incorporating some tiny changes in the scheme (Fig. 4.3). Aspects of individual biostratigraphical units are discussed further on in the corresponding paragraphs.

DISCUSSION OF PROPOSED BIOSTRATIGRAPHIC UNITS

In the following paragraphs, all biostratigraphic units (levels, zones, horizons, associations and intervals) proposed within the Jince Formation of the Příbram-Jince Basin are discussed and commented. All these units are arranged in chronological order under the original English designation and/or translation. They are numbered from the first unit (number 1) to the most recent proposal and/or modification (number 37).

1. Level *a* with *Paradoxides rugulosus*
Established by Šuf (1926, p. 133). Discussion see *(7)* Eccaparadoxides pusillus Taxon-range Zone.

2. Level *b* with *Stromatocystites pentangularis*
Established by Šuf (1926, p. 134). Discussion see *(8)* Stromatocystites pentangularis Zone.

3. Level *c* with *Paradoxides bohemicus*
Established by Šuf (1926, p. 133). Discussion see *(9)* Paradoxides gracilis Taxon-range Zone.

4. Level *d* with *Ellipsocephalus Hoffi*

Established by Šuf (1926, p. 133). Discussion see *(29)* Rejkocephalus-Lingulella Assemblage Zone.

5. Level *e* with *Lingulella Walcotti*

Established by Šuf (1926, p. 133). Discussion see *(29)* Rejkocephalus-Lingulella Assemblage Zone.

6. Paradoxides spinosus and Stromatocystites pentangularis Zone

Established by Kettner and Bouček (1936). Discussion see *(8)* Stromatocystites pentangularis Zone.

7. Eccaparadoxides pusillus Taxon-range Zone

The name and original concept of the "Level *a* with *Paradoxides rugulosus*" proposed by Šuf (1926, p. 133), coincides with the Paradoxides rugulosus Zone of Kettner and Bouček (1936), Šnajdr (1950), and Šnajdr and Havlíček (1951) and the Eccaparadoxides pusillus Taxon-range Zone as redefined by Šnajdr (1958 and 1975b); the designation of this unit has been used in its original understanding by all later workers, with the exception of Havlíček (1971), who incorporated the Stromatocystites Facies (i.e. the overlying sequence up to the base of the P. gracilis Zone – see Fig. 3.1). Fatka (1989), Fatka and Kordule (1992) and Kordule (1996) distinguished within this zone two/and or three subzones and two horizons, respectively (see Figs. 3.3, 4.1, 2).

Remarks: Eccaparadoxides pusillus and the Paradoxides gracilis taxon-range zones are the most persistent Cambrian biostratigraphical units of the Příbram-Jince Basin.

8. Stromatocystites pentangularis Zone

The name, "Level *b* with *Stromatocystites pentangularis*", was applied originally by Šuf (1926, p. 134) for the sequence situated betwen his "Level *a* with *Paradoxides rugulosus*" and the "Level *c* with *Paradoxides bohemicus*". The designation S. pentangularis Zone was later used by Šnajdr (1950, 1958) and Havlíček and Šnajdr (1951). Prokop (1960, p. 42) established presence of the genus *Stromatocystites* Pompeckj, 1896 in the overlying P. gracilis Zone, *Stromatocystites* was later ascertained also in the underlying E. pusillus Zone (Šnajdr 1975b, p. 157). Consequently Šnajdr (1975b p. 157) proposed to rename the S. pentangularis Zone into the Hydrocephalus minor Zone. Because specimens of the trilobite genus *Hydrocephalus* Barrande, 1846 emend. Šnajdr, 1958 occur commonly both below as well as above this Šnajdr's zone, Fatka (1989) and Fatka and Kordule (1992) recommended to designate the discussed layers as the E. pusillus–P. gracilis Interval (Figs. 3.3, 4.1). More recently Kordule (1996, p. 43) labeled these layers as Interval zone B (inconsequently called sometimes as Interval B) (Fig. 4.2). Havlíček (1998) used as a compromise the name Stromatocystites and Hydrocephalus minor Zone.

9. Paradoxides gracilis Taxon-range Zone

For the first time this part of sequence was designated as a "Level *c* with *Paradoxides bohemicus*" by Šuf (1926, p. 133) and used by Kettner and Bouček in the sense of zone. Later on Prantl (1940) changed the formal name of the index species into *Paradoxides gracilis* and Šnajdr (1950) adapted

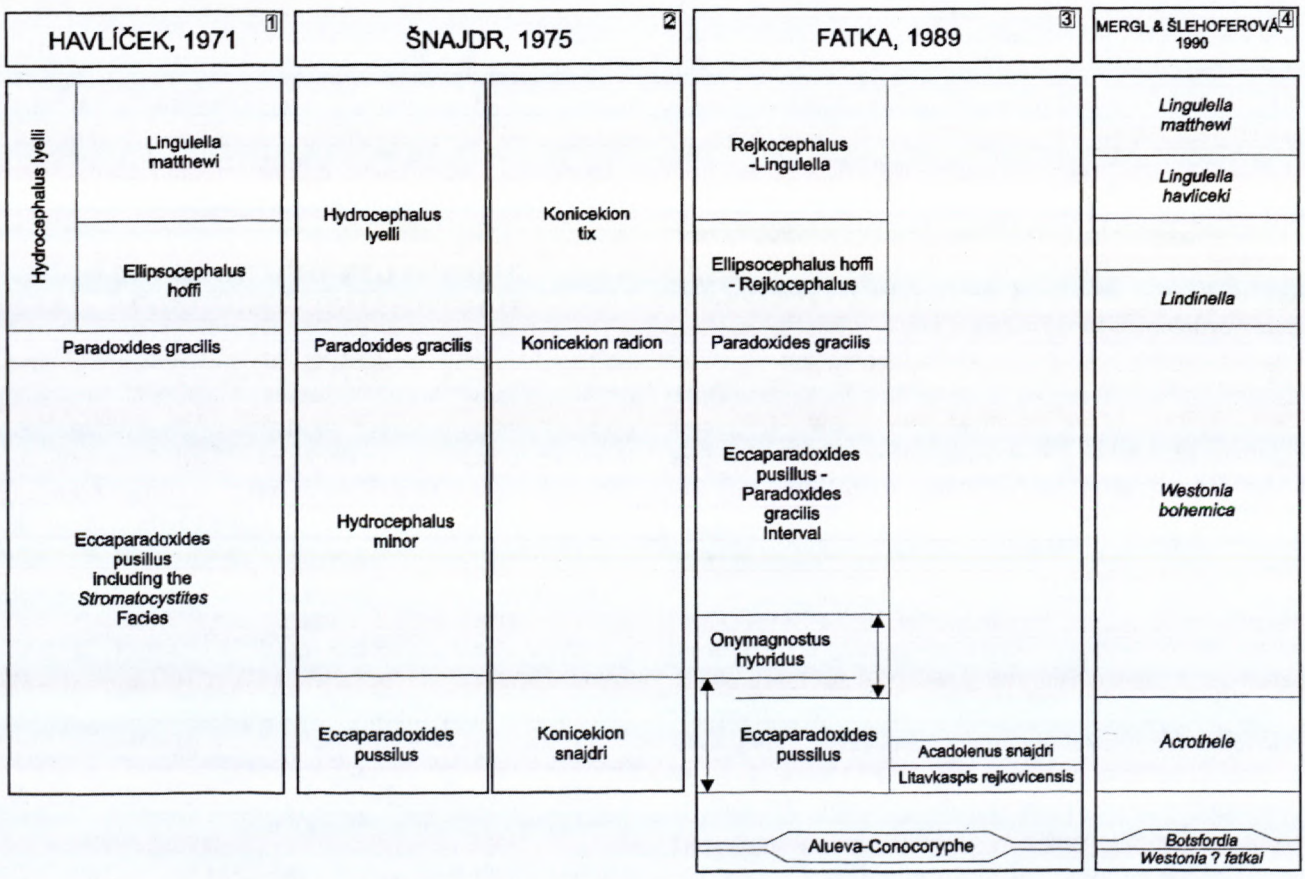


Fig. 3. Comparison of biostratigraphical subdivision of the Jince Formation proposed by: 1. Havlíček (1971), 2. Šnajdr (1975), 3. Fatka (1989), and 4. Mergl and Šlehoferová (1990).

the designation into *Paradoxides gracilis* Zone, even later Šnajdr (1975b) applied this unit in the sense of taxon-range zone.

Remarks: Paradoxides gracilis Taxon-range Zone is together with the Eccaparadoxides pusillus Zone the most persistent biostratigraphical units within the Jince Formation.

10. Ellipsocephalus hoffi Zone

For the first time this part of sequence was designated as the "Level *d* with *Ellipsocephalus Hoffi*" by Šuf (1926, p. 134), later on Šnajdr (1958, p. 22) proposed to use it as an older subzone within the newly defined Hydrocephalus lyelli Zone and finaly Šnajdr (1975b, p. 159) concluded that it is impossible to apply the nominate species for biostratigraphical purposes. Discussion see *(29)* Rejkocephalus-Ligulella Assemblage Zone.

11. Lingulella matthewi Zone

Šuf (1926, p. 134) suggested to call the youngest layers of the Jince Formation as "Level *e* with *Lingulella Walcotti*". All subsequent authors used this designation in the sense of subzone (Šnajdr, 1950; Šnajdr and Havlíček 1951; Šnajdr, 1958; Havlíček 1971), and/or association (Mergl and Šlehoferová 1990) and/or assemblage zone (Fatka and Kordule 1992; Kordule 1996). Only Šnajdr (1975b, p. 159) came to the conclusion of inapplicability of this biozone, because of presence of the species *L. matthewi* already in the P. gracilis Zone. Mergl and Šlehoferová (1990, p. 84) quoted the index species from the upper part of the Rejkocephalus-Lingulella Assemblage Zone. Discussion see *(29)* Rejkocephalus-Ligulella Assemblage Zone.

12. Hydrocephalus lyelli Zone

The name, Hydrocephalus lyelli Zone, was used first by Šnajdr (1950, p. 211) for a segment of the succession earlier designated by Šuf (1926) as the "Level *d* with *Ellipsocephalus hoffi*" and "Level *e* with *Lingulella Walcotti*", respectively. This zone was used without any change in all successive divisions (Šnajdr and Havlíček 1951; Šnajdr 1958; Havlíček 1961, 1963). Later on, Šnajdr (1975b, p. 159) stressed, that the index species – *E. hoffi* and *L. matthewi* show much larger stratigraphical ranges and thus cannot be applied in detailed biostratigraphy. Mergl and Šlehoferová (1990, p. 72–73) divided higher parts of the discussed interval into the Lindinella, Lingulella havliceki and Lingulella matthewi associations (Fig. 3.4). Fatka and Kordule (1992, p. 58) reviewed the history and usage of this unit and proposed to designate the highest portions of the succession as the E. hoffi-Rejkocephalus and Rejkocephalus-Lingulella assemblage-zones, respectively. Discussion see *(29)* Rejkocephalus-Ligulella Assemblage Zone.

13. Hydrocephalus minor Zone

Established by Šnajdr (1975b, p. 157). Discussion see *(8)* Stromatocystites pentangularis Zone.

14. Konicekion snajdri Zone, Konicekion radion Zone, and Konicekion tix Zone

All three zones were established by Šnajdr (1975a, p. 158) only in a table 1, without any definition and/or discussion. In the preceeding paper this author expressed the following idea.: "... The stratigraphical range of single species is somewhat narrow, being always confined to a certain zone.

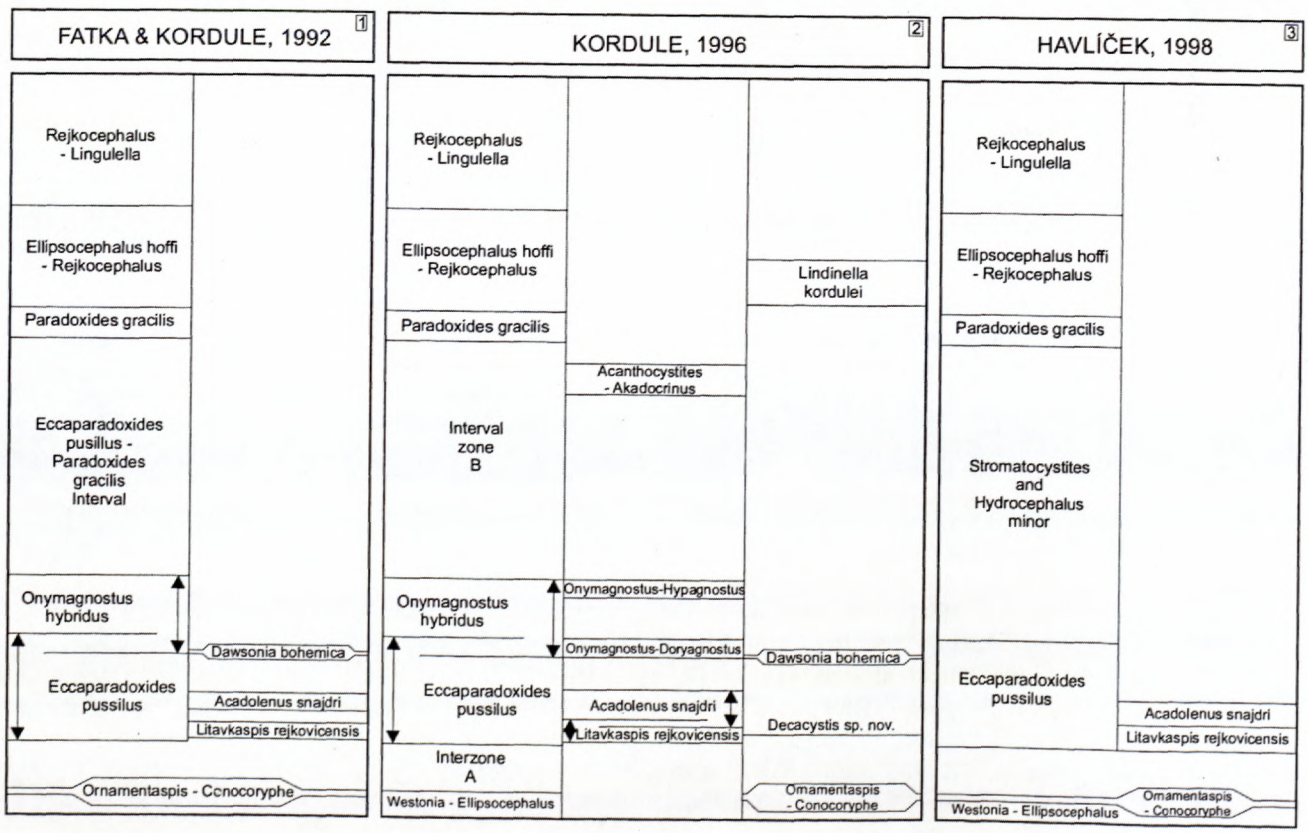


Fig. 4. Comparison of biostratigraphical subdivision of the Jince Formation proposed by: 1. Fatka and Kordule (1992), 2. Kordule (1996), and 3. Havlíček (1998).

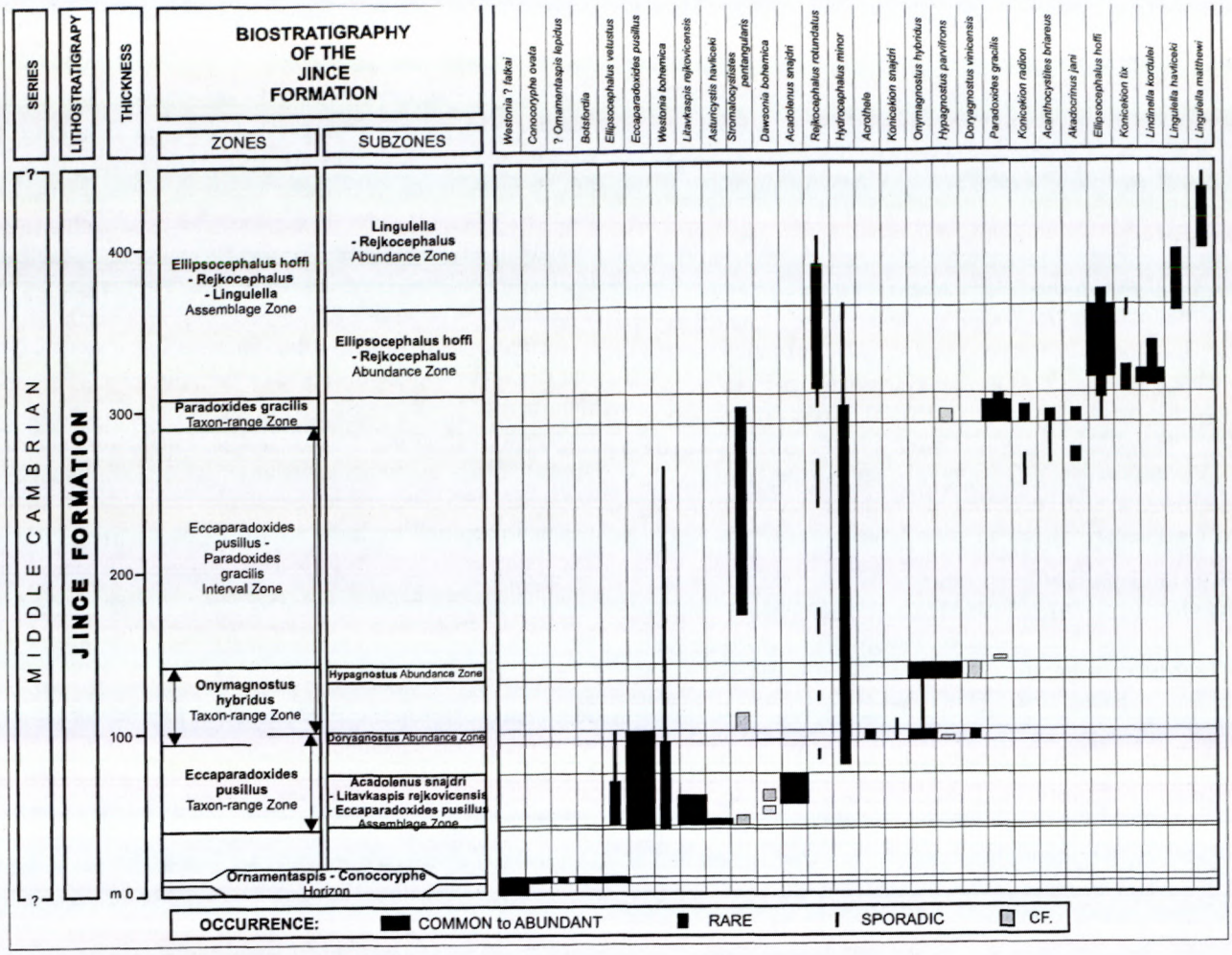


Fig. 5. Stratigraphical ranges of taxa applied for biostratigraphic subdivision of the Jince Formation.

This feature, however, is of no practical importance because of sporadical occurrence" (Šnajdr 1975b, p. 154).

Discussion: Rare occurrence and high morphologic similarity of all three taxa are the limiting factors for practical application of the genus *Konicekion* Šnajdr, 1975 in biostratigraphical subdivision of the Middle Cambrian Jince Formation.

15. Alueva-Conocoryphe Horizon

Established by Fatka (1989, p. 26) as the Alueva--Conocoryphe Biohorizon, further defined as Ornamentaspis-Conocoryphe Horizon by Fatka *et al.* (1992, p. 86). Detailed discussion see *(22)* Ornamentaspis--Conocoryphe Horizon.

16. *Westonia? fatkai* Association

Established by Mergl and Šlehoferová (1990, p. 69).

Discussion: This low-diversity association has been established in a sequence interpreted by Mergl and Šlehoferová (1990) and Fatka *et al.* (1992) as shallow subtidal rough-water environment at one locality only (Vinice Hill near Jince). Because of this association is documented solely from only one locality, its applicability is limited. Kordule (1996, p. 40, 45) renamed the layers containing the index species as the Westonia--Ellipsocephalus Assemblage Zone.

17. *Botsfordia* Association

Established by Mergl and Šlehoferová (1990, p. 70).

Discussion: This association is known only from the Ornamentaspis-Conocoryphe Horizon at the Vinice Hill near Jince.

18. *Acrothele* Association

Established by Mergl and Šlehoferová (1990, p. 70), without discussing stratigraphic range and both lower and upper boundaries of this association.

19. *Westonia bohemica* Association

Established by Mergl and Šlehoferová (1990, p. 70) without discussing stratigraphic range as well as lower and upper boundaries of this association.

20. *Lindinella* Association

Established by Mergl and Šlehoferová (1990, p. 72), without discussing stratigraphic range as well as lower and upper boundaries of this association. Later Kordule (1996, p. 41–42, 46) modified designation on the *Lindinella kordulei* Horizon.

Discussion: Kordule (1996, p. 41–42, 46) affirms that the most abundant occurrence of the index species lies about 6 m above the P. gracilis Zone. The denomination in the sense of association fits better with the occurrence of *L. kordulei* in different levels of the Jince Formation (i.e. in Medový Újezd – Mergl and Šlehoferová 1990, p. 77).

21. *Lingulella havliceki* Association

This association has been proposed by Mergl and Šlehoferová (1990, p. 72) for the brachiopod dominated layers, without defining its lower and upper boundaries. This association is documented from the lower part of the Rejkocephalus-Lingulella Assemblage Zone (Mergl and Šlehoferová 1990, p. 85).

22. Ornamentaspis-Conocoryphe Horizon

The original understanding of this biohorizon as established by Fatka (1989 – under the designation Alueva--Conocoryphe Horizon) was later discussed by Fatka *et al.* (1992, p. 86) and has been followed by all successive authors.

Discussion: The index trilobite species *Ornamentaspis lepidus* Fatka et al., 1992 associated with other typical trilobites has been established in several tens centimentres thick layer some 5 metres above the base of the Jince Formation at the type locality Vinice near Jince only. Base of the Jince Formation is defined arbitrarily by the upper surface of the last sandstone-conglomerate bank at the Vinice Hill near Jince. The sequence of fine sandstones with layers of greywackes (containing rare specimens of inarticulate brachiopods and trace fossils), underlying the last sandstone-conglomerate bank, should be classified as belonging to the Chumava-Baština Formation.

23. Litavkaspis rejkovicensis Taxon-range Zone

This zone was differentiated by Fatka and Kordule (1992, p. 56) as a subzone within the lowest part of the E. pussilus Zone and was accepted by all following authors.

24. Acadolenus snajdri Taxon-range Zone

The zone was established by Fatka and Kordule (1992, p. 56–57) as a subzone in the lower half of the E. pussilus Zone; this designation has been used by all later workers in the original sense. The only change was published by Kordule (1996, p. 40, 45) who established a longer stratigraphic range of the index trilobite *L. rejkovicensis* (see above).

25. Dawsonia bohemica Horizon

Šnajdr (1975b, Table 1 on p. 158) first suggested that the stratigraphically restricted range of the index species could be applied as a marked horizon but he did not discuss this proposal. Fatka and Kordule (1992, p. 57) shortly mentioned the D. bohemica Horizon as 80–120 cm thick sequence with abundant index species associated with several other species of miomerid trilobites. Recently, *Dawsonia* cf. *bohemica* has been established in the lower part of the E. pusillus Zone (Kordule 1996, p. 41, 45, Fatka et al. in press, Fig. 5).

Discussion: The Dawsonia bohemica Horizon represents a very important level within the E. pussilus Zone (lowermost levels of the O. hybridus Zone) in the sense of abundance zone.

26. Eccaparadoxides pusillus-Paradoxides gracilis Interval Zone

Established by Fatka and Kordule (1992, p. 57–58). Discussion see *(8)* Stromatocystites pentangularis Zone.

27. Onymagnostus hybridus Taxon-range Zone

Sudden common occurrence of miomerid trilobites in the upper part of the E. pussilus Zone on Vinice near Jince evoked the designation of this zone (Fatka and Kordule 1992, p. 57).

Discussion: Two new biostratigraphical units were proposed inside the O. hybridus Zone by Kordule (1996, p. 41, 45–46); namely the Onymagnostus-Doryagnostus Assemblage Zone in the uppermost portion of the E. pussilus Taxon-range Zone and the Onymagnostus-Hypagnostus Assemblage Zone in rocks overlying the E. pussilus Taxon-range Zone. This subdivision has been based on data from the Vystrkov Hill. It is possible to conclude that the index species *Hypagnostus parvifrons* is common to abundant in the upper part of the O. hybridus Zone, but is also rarely present in other levels (e.g. in the lower portion of P. gracilis Zone – reported here as Hypagnostus fatkai Kordule et Šnajdr, 1979). The index species *Doryagnostus vinicensis* is common to abundant in lower part of the O. hybridus Zone but ranges to the upper part of this zone.

Conclusion: Application of two index species for definition of assemblage zone has not been in agreement with rules of the Second Edition of the Stratigraphic guide already in the year 1996. Both zones proposed by Kordule (1996) are to be treated as levels of common occurrence of the index taxa with the O. hybridus Taxon-range Zone (as defined by Fatka and Kordule, 1992) and/or within the O. hybridus-D. vinicensis-H. parvifrons Assemblage-range Zone.

28. Ellipsocephalus hoffi-Rejkocephalus Assemblage Zone

Established by Fatka and Kordule (1992, p. 58) for the upper part of the Jince Formation. Discussion see *(29)* Rejkocephalus-Lingulella Assemblage Zone.

29. Rejkocephalus-Lingulella Assemblage Zone

Established by Fatka and Kordule (1992, p. 58) for the uppermost part of the Jince Formation.

Discussion: To establish a good biostratigraphical subdivision for the sequence overlying the P. gracilis Taxon-range Zone represents a substantial problem. All groups of trilobites (both miomerid and polymerid), hyolithids and inarticule brachiopods are gradually fading away as resulting from the progressive filling, shallowing and more and more limited marine conditions of the sedimentary basin. Resistant forms, surviving under such conditions, belong to the long-ranging taxa, unsuitable for biostratigraphic purposes. Conclusion: The optimal solution of biostratigraphic subdivision would be to establish the new assemblage zone defined in agreement with the Second Edition of the Stratigraphic guide, using the taxa Rejkocephalus, E. hoffi and Lingulella as the index taxa of assemblage-zone.

30. Westonia-Ellipsocephalus Assemblage Zone

Established by Kordule (1996, p. 40, 45), who substituted the designation *Westonia*? *fatkai* Association of Mergl and Šlehoferová by this designation.

Problems: As index species it is unavoidable to use at least three taxa for definition of any assemblage zone. In addition, this zone is known from one outcrop only.

31. Interzone A

Established by Kordule (1996, p. 40, 45). The lower boundary of this unit is given by the last occurrence of fauna

about 1 m above the Ornamentaspis-Conocoryphe Horizon, the upper limit is defined by the FAD of the polymeroid trilobite *Eccaparadoxides pusillus*, the index form of the overlying biozone.

Problems: Similarly as some other units proposed by Kordule (1996), also base of this interval is documented from the only one outcrop.

32. Interzone B

Established by Kordule (1996, p. 40). Discussion see *(8)* Stromatocystites pentangularis Zone.

33. Onymagnostus-Doryagostus Assemblage Zone

Established by Kordule (1996, p. 41, 45). Discussion see *(27)* Onymagnostus hybridus Zone.

34. Onymagnostus-Hypagnostus Assemblage Zone

Established by Kordule (1996, p. 41, 45–46). Discussion see *(27)* Onymagnostus hybridus Zone.

35. Decacystis n. sp. Horizon

Kordule (1996, p. 40, 45) defined this horizon as the "... zone of maximum abundance of the genus of *Decacystis*, small in thickness (30 cm)", i.e. in the sense of acme-zone of the species *Asturicystis havliceki* Fatka et Kordule, 2001.

36. Acanthocystites-Akadocrinus Assemblage Zone

This zone was defined by Kordule (1996, p. 41, 46) as about 8 metres thick subzone in the upper part of his Interzone B.

Problems: As index species it is unavoidable to use at least three taxa for definition of any assemblage zone. In addition, both taxa are known also higher in the sequence (i.e. in the P. gracilis Zone). Common occurrence of both eocrinoid genera *Acanthocystites* and *Akadocrinus* in given part of the Jince Formation is most probably influenced by redeposited material originated under apropriate environment (compare Álvaro and Vennin 1997).

37. Lindinella kordulei Horizon

Defined by Kordule (1996, p. 41–42, 46). Discussion see *(20) Lindinella* Association.

CONCLUSION

The author recommends to use biostratigraphic subdivision of the Jince Formation within the Příbram-Jince Basin as shown in the Fig. 5, i. e. to distinguish the following units:

Ornamentaspis-Conocoryphe Horizon.

Eccaparadoxides pusillus Taxon-range Zone (with the Acadolenus snajdri-Litavkaspis rejkovicensis- Eccaparadoxides pusillus Assemblage Zone as a Subzone in its lower portion).

Dawsonia bohemica Horizon.

Onymagnostus hybridus Taxon-range Zone (with the Doryagnostus Abundance-zone and Hypagnostus Abundance-zone as subzones).

Eccaparadoxides pusillus-Paradoxides gracilis Interval zone.

Paradoxides gracilis Taxon-range Zone.

Ellipsocephalus hoffi-Lingulella-Rejkocephalus Assemblage Zone (with the Ellipsocephalus hoffi-Rejkocephalus Abundance Zone and Lingulella-Rejkocephalus Abundance Zone, as subzones).

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A PRELIMINARY REPORT ON *PARACITELLUS EMINENS* DEHM, 1950 (APLODONTIDAE, AILURAVINAE, RODENTIA, MAMMALIA) FROM THE EARLY MIOCENE OF NW BOHEMIA

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Abstract: Remains of dentition of the primitive ailuravine rodent *Paracitellus eminens* Dehm, 1950 are reported from the MN 3 deposits of the open brown coal pit Merkur-North (north-western Bohemia). The specimens are larger than those from the Wintershof-West and from the Ulm-Westtangente (Germany). In their size they correspod to the stratigraphically older species *Paracitellus cingulatus* Heissig, 1979 from the MP 21 karstic fillings Möhren 13 and 19, and Haag 2 (Schwäbiche Alb, Bavaria, Germany).

INTRODUCTION

The open-cast mine Merkur-North situated in the central part of the Tertiary Most Basin (north-western Bohemia), revealed a rich fossil record (coprolites, ichnofossils, molluscs, vertebrates). The mammalian fauna of the site was reported by Fejfar (1974, 1990, 1998), including several species of aplodontid rodents, viz. *Ameniscomys selenoides* Dehm, 1950, the most progressive hypsodont aplodontid rodent in Europe (Fejfar, 1990), *Sciurodon descendens* Dehm, 1950 and *Sciurodon* cf. *descendens* Dehm, 1950. The last two were reported from the drilling samples at Kralupy near Chomutov, Northern Bohemia already by Čtyroký *et al.* (1964) from the horizon corresponding to the base of the main coal seam at the now existing open-cast mine Merkur-North. The same layer provided also an ailuravine rodent, *Paracitellus eminens* Dehm, 1950, which is reported in the present paper.

SYSTEMATIC PART

Family: *Aplodontidae* Trouessart, 1897 (sensu Rensberger, 1975)
Subfamily: *Ailuravinae* Michaux, 1968

Genus: *Paracitellus* Dehm, 1950
Type species: *Paracitellus eminens* Dehm, 1950

Stratigraphical range: Lower Oligocene to Middle Miocene.

Remarks: More than fifty years ago, Dehm (1950) described 48 lower jaws and 130 isolated teeth from the karstic filling Wintershof-West as new genus and species *Paracitellus eminens*, besides of the other two forms *Paracitellus* n. sp. A. and *Paracitellus* n. sp. B. Heissig (1979) referred the genus *Paracitellus* Dehm, 1950 to the family *Aplodontidae* Trouessart, 1897 (subfamily *Ailuravinae* Michaux, 1968) on the basis of dental morphology and morphology of lower jaw.

Five species of the genus *Paracitellus* are currently recognized: the three above-mentioned taxa which come from the karstic filling Wintershof-West (MN 3) and from the stratified site Ulm-Westtangente (MN 2a) (Werner 1994); two other, *P. cingulatus* Heissig, 1979 and *P. marmoreus* Heissig, 1979 were described from the karstic localities Möhren 13, 19 (MP 21) and Haag 2 (MP 21). The specimens of *P. eminens* are intermediate in size, while the specimens of *P. cingulatus* are the largest and the specimens of *P. marmoreus* are the smallest. Up to now, no information is available on the postcranial skeleton of this genus.

Paracitellus eminens Dehm, 1950
Figs. 1–2

1950 *Paracitellus eminens* n. sp.; Dehm, 350–359, Abb. 34–40
1994 *Paracitellus eminens* Dehm 1950; Werner, 173– 175, Abb. 117

Type locality: Wintershof-West (MN3 – Lower Miocene, Orleanian)
Type material: *Paracitellus eminens* Dehm, 1950, pp. 350–359, figs. 24–33
Locality: Merkur-North (MN 3), the open-cast mine Merkur (Most Basin, Bohemia).

Material and measurements: 8 isolated teeth and 2 teeth in a lower jaw: ZD MN 2001d 1–10.

Measurements are given in millimetres. The length has been taken as the largest perpendicular distance between anterior and posterior margins of tooth. The width has been taken as the largest perpendicular distance between buccal and lingual margins of tooth.

1 p4 dex (4.25 x 3.51); 1 m1,2 dex (4.42 x 3.97); 2 m1,2 sin (4.42 x 3.7), (4.88 x 4.06);
1 m^3 sin (5.61 x 4.24); 1 P4 sin (4.2 x 4.26); 1 M1,2 sin (4,25 x 4.47); 1 M1,2 dex (4.21 x 4.19); 1 M3 sin (4.03 x 3.92)

Description: (Dental morphology terminology using after Heissig, 1979) The upper molars and premolars have very high and sheer cones and conules. The protoconule is lower than metaconule. The mesostyle is absent. Protocone is large and separated from anteroloph. Anteroloph is low and extends in cingulum. The protoloph and metaloph are partly created by base of conules and partly by low, abrupt crests. The particular morphological characters are well-marked in specimens from Merkur-North as well as by specimens of *P. eminens* from Wintershof-West and identical with the specimens from Ulm-Westtangente as could be concluded according to the detailed drawing by Werner (1994) and a more schematic drawing by Dehm (1950)).

Discussion: The specimens described by Heissig (1979) as *P. cingulatus* exhibit a well developed mesostyl and P4 buccal cingulum, *P. marmoreus* is specific by weakly developed mesostyl and buccal cingulum. The protoconule and metaconule are weakly developed, similar as hypocone. The cusps of the lower cheeck teeth are also very well developed. Posterolophid may be divided by small hypoconulid and sharp endoconid. The connection of anterolophid with several smallest stylids between protoconide and metaconide of m1, 2 (in suggestion in p4 also) is typical for specimens from Merkur-North, and different from the populations from Wintershof-West and Ulm-Westtangente. The morphology of the occlusal surface of the specimens from Bohemian Neogene fits the description given by Dehm (1950) and Werner (1994).

The specimens from Merkur-North are generally larger than the type material. Their size is comparable with *P. cingulatus* (Fig. 1). I agree with the opinion of de Bruijn (1998) that the differences between the measuring techniques used by different authors could strongly influence the data; therefore it seems unwise to plot the

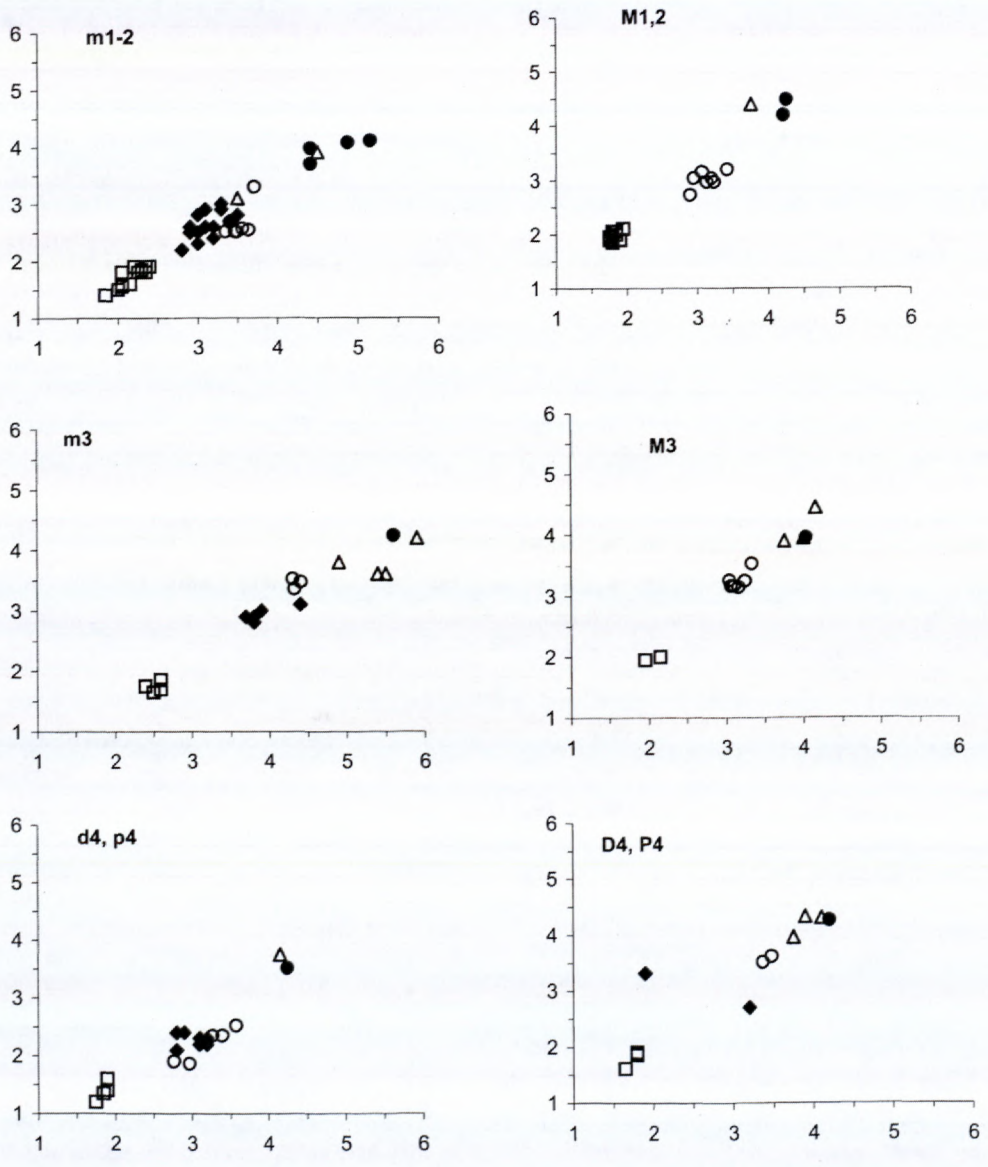


Fig. 1. Scatter diagram of length/width parameters of cheeck teeth of *Paracitellus*. Legend: x axis – length (in mm), y axis – width (in mm), • Merkur, ◆ Wintershof-West, o Ulm-Westtangente, *Paracittelus marmoreus* from Möhren and Haag, ▲ *Paracittelus cingulatus* from Möhren and Haag.

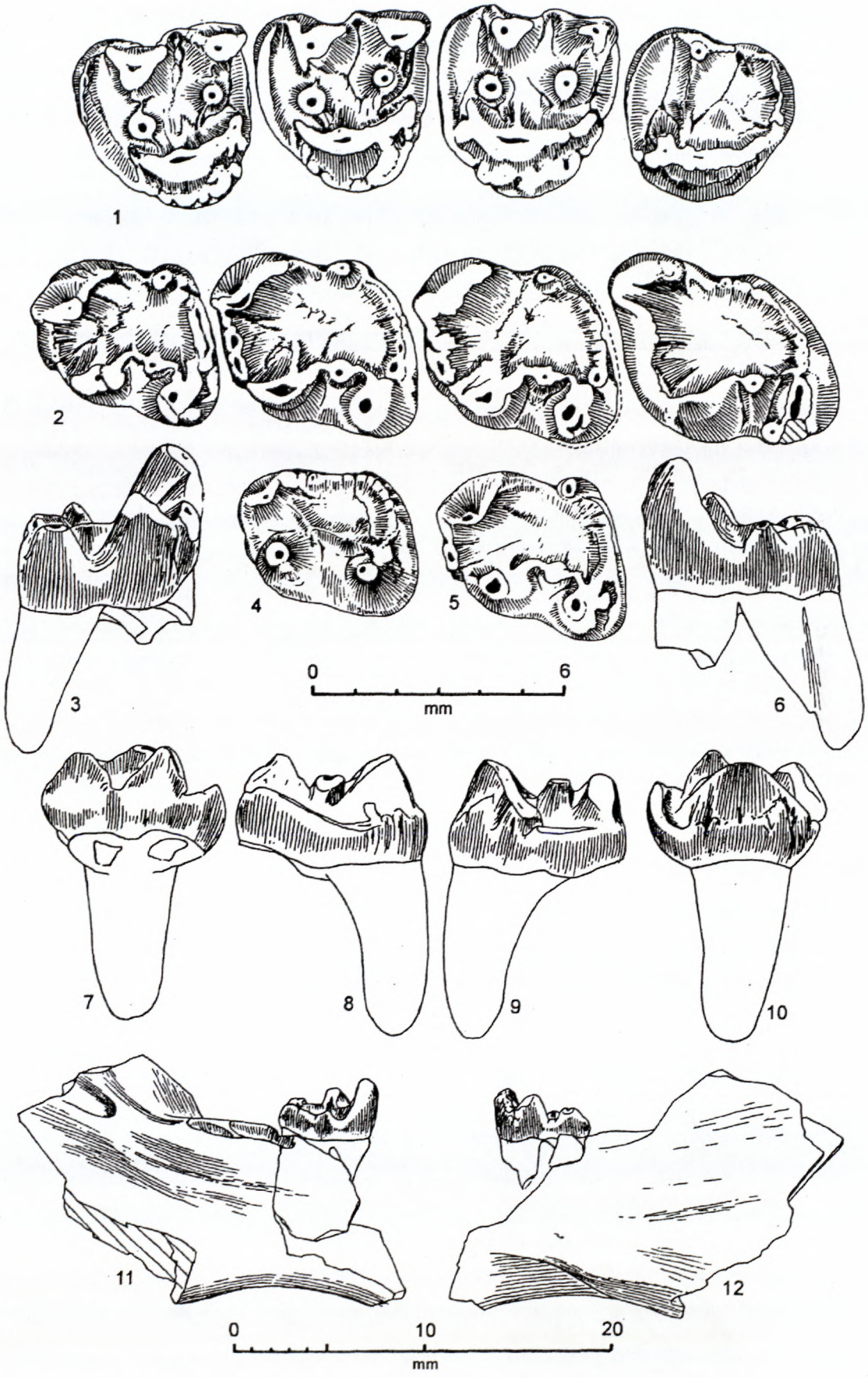


Fig. 2. Upper and lower cheeck teeth of *Paracitellus eminens* Dehm, 1950 from Merkur-North. Drawn by Prof. O. Fejfar (Faculty of Science, Charles University, Prague).
1. Upper premolar and molars P4, M1 – M2, M3 (occlusal view). 2. Lower premolar and molars p4, m1 – m^2, m^3 (occlusal view). 3. Lower molar m1,2 (buccal view). 4. Lower d4 or p4 (occlusal view). 5. Lower molar m1,2 (occlusal view). 6. Lower molar m1,2 (linqual view). 7. Upper molar M1,2: buccal, messial (8), posterior (9) and the last linqual (10) views. 11. Lower jaw with m2: linqual and buccal (12) views.

measurements from the literature in one diagram and reach a conclusion on such basis. However, the difference in size between the specimens from Merkur-North and the specimens from Wintershof-West and Ulm-Westtangente is so apparent, that the difference really exists. The locality Merkur-North represents the base of main coal seam, while Wintershof-West is the fissure filling locality; hence, the sites differ much also in habitat pattern which they represent. It is thus a matter of discussion to which degree the differences found in the respective populations reflected also the differences in habitats and also the different quality of food. The differences in dental morphology among the populations from Merkur-North, Wintershof-West and Ulm-Westtangente are minute and may even result rather of different preservation and different level of abrasion of the teeth.

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PLATANOID STAMINATE INFLORESCENCE AND ITS ASSOCIATED FOLIAGE FROM THE BOHEMIAN CENOMANIAN (CZECH REPUBLIC)

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Abstract: A platanoid staminate inflorescence from the Cenomanian of the Peruc-Korycany Formation in the Czech Republic is described. It is the first well-preserved platanoid reproductive structure recorded in the Bohemian Cenomanian area. The inflorescences are globular with pentamerous flowers characterized by a well-developed perianth and androecium. Each stamen has a short filament and a large wedge-shaped apical extension of its connective. Pollen grains preserved *in situ* are tricolporate with microreticulate sculpture. Possible association with leaves of *"Platanus" laevis* (Velenovský) Velenovský is suggested. Both organs are recorded in the same layer. Comparison to other Cretaceous genera of the Platanaceae and species of *Platananthus* is discussed.

INTRODUCTION

The Platanaceae has one of the longest fossil records of any angiosperm family. They are recognized from the mid-Cretaceous strata onward through to recent. Their fossil leaves have been known since the time of Zenker (1833). Cretaceous platanoid leaves are typical in lobation and characteristic venation pattern. They are recorded from many localities in Europe (Czech Republic – Velenovský 1882, Krasser 1896, Knobloch 1964, 1995; Germany – e.g. Rüffle 1968, 1975), Greenland (e.g. Seward 1926, Boyd 1998), the United States (e.g. Lesquereux 1892), Russia (e.g. Baikovskaya 1956, Herman and Golovneva 1988, Herman 1994), Kazakhstan (Shilin 1986). Tertiary records of the Platanaceae are even more numerous and more diversified in the Northern Hemisphere (e.g. Bůžek *et al.* 1967, Crane *et al.* 1988, Pigg and Stockey 1991, Kvaček, Z. *et al.* 2001).

Cretaceous platanoid inflorescences were less frequently recorded. During last few decades information on staminate and pistilate inflorescences from various Cretaceous localities within the Northern Hemisphere has been accumulated (Dilcher 1979, Knobloch and Mai 1986, Friis *et al.* 1988, Krassilov and Shilin 1995, Crane *et al.* 1993, Pedersen *et al.* 1994, Magallón-Puebla *et al.* 1997, Maslova 1997).

The Peruc – Korycany Formation is comparatively rich in platanoid foliage. Bronn (1838), Velenovský (1882), and Krasser (1896) described several species, which are under current revision [e.g. *Platanus cuneifolia* (Bronn) Krystofovich, *Platanus laevis* (Velenovský) Velenovský, *Platanus bohemica* (Velenovský) Knobloch, *Platanus velenovskyana* Krasser]. The first Cretaceous records of platanoid fructifications were published by Velenovský (1889). He studied impressions of possibly female globose structures associated tentatively with leaves of *Platanus laevis* in the locality Vyšehořovice.

This paper reports on a new discovery of lignified specimens of platanoid inflorescence from the Bohemian Cenomanian. The material from the Pecínov locality provides evidence of pollen produced by platanoid inflorescences and suggests their association with platanoid foliage recorded in the same layer.

MATERIAL AND METHODS

The material described herein was collected in summer 2000 by the author. New material was compared to the original Velenovský's type specimens and other relevant material housed in the National Museum, Prague. All specimens come from the Peruc-Korycany Formation of the Bohemian Cretaceous Basin. The specimens described by Velenovský (1882, 1889) come from the localities Vyšehořovice, Mělník, Prague-Slivenec, and Prague-Malá Chuchle. The new material comes from the Pecínov Quarry (60 km west of Prague), within fluvial mudstone lenses (unit 2 according to Uličný *et al.* 1997).

One part of the globose inflorescence was isolated by treatement in HF in standard way (e.g. Eklund and J. Kvaček 1998). Specimens were mounted on SEM stubs, coated with gold and observed by Jeol SEM. Measurements were done directly from scanning micrographs.

Cuticles of leaves were prepared by standard technique published e.g. by Eklund and J. Kvaček (1998). The specimens and preparations studied are housed in the collection of the National Museum, Prague.

SYTEMATICS

Family Platanaceae

Staminate inflorescence

Platananthus Manchester 1986

Type: *Platananthus synandrus* Manchester 1986: 212, emend. Friis *et al.* 1988: 10

Platananthus sp.
Pl. 1

Locality: Pecínov, 40 km west of Prague.
Age: Cenomanian, Late Cretaceous.
Stratum: Peruc-Korycany Formation, Peruc Member, unit 2 *sensu* Uličný *et al.* 1997.

Description. This probably new species of *Platananthus* is represented by a single hand-specimen (F 2904) showing two heads of staminate inflorescence. Both heads are 15 mm close to each other and were probably attached to the common peduncle.

Globose staminate heads are composed of a spherical receptacular core and are built of numerous, radially arranged, closely spaced staminate flowers (Pl. 1, fig. 1). Heads are 8–14 mm in diameter. Each flower consists of five stamens surrounded by prominent tepals (pl. 1, figs. 3, 4). Stamens have elongate anthers 1–1.6 mm long. Their connectives are typically massive, peltate to conical 0.3–0.6 x 0.6–1.0 mm in size and sharply delimited from the thecae (Pl. 1, figs. 2, 5, 6). Filaments are difficult to observe and are possibly quite short. Massive tepals (0.8 x 2.2 mm) shown in the pl. 1 figs. 3, 4 and partly preserved in the fig. 7 are lanceolate to oblanceolate, apically expanded and longer than stamens. Their epidermis bears trichome bases (pl. 1, fig. 11).

Pollen grains occur occasionally in clusters (Pl. 1, fig. 10) traped in the wrinkles of possible pollen sacs. Pollen grains are tricolporate, spheroidal and typically 18–22 x 12–15 μm in diameter, with microreticulate sculpture (Pl. 1, fig. 9). The reticulum has thick muri and irregularly polygonal, rounded lumina.

Pollen grains adhering on leaves of *Platanus laevis* show the same form, size and microreticulation as those recorded *in situ*. Pollen from leaves observed in light microscope showed inner structures of pollen with pores deeply sunken in the pollen body.

Discussion. The genus *Platananthus* was established by Manchester (1986) on both silicified and lignified material from the Eocene of USA (the Clarno Nut Beds). It differs from the recent genus *Platanus* L. in number of stamens, size of anthers, small size of pollen, and well-developed perianth. The genus was later emended by Friis *et al.* (1988) for accommodation of Cretaceous staminate platanoid inflorescences. *Platananthus* sp. differs from the type of the genus, *Platananthus synandrus*, from the Eocene of Oregon (Manchester 1986) in well pronounced peltate connectives and in a tendency of the anthers to be dispersed singly rather than in clusters of five.

Although the type specimen is Eocene in age, male inflorescences most similar to *Platananthus* sp. are coming from the Cretaceous. *Platanathus potomacensis* Friis *et al.* (1988) from the Upper Albian of Maryland, USA is characterized by charcoalified material showing fragmentary inflorescences and isolated flowers. It differs from the Bohemian material in more expanded extensions of connectives, which are weakly delimited from anther thecae, and in absence of trichomes. *P. hueberi* Friis *et al.* from the Santonian-Campanian of the Black Creek Formation, North Carolina (Friis *et al.* 1988) is represented by compressed circular inflorescences. It differs from *Platananthus* sp. in thinner, membranaceous tepals and the morphology of pollen exine showing large polygonal lumina. *P. scanicus* from the Santonian-Campanian of Scania, Sweden (Friis *et al.* 1988) differs from *Platananthus* sp. in expanded apical parts of tepals and more elongated apical extensions of the connective.

Another platanoid genus *Hamatia* Pedersen *et al.* (1994) differs in more prominent characters. The type species *Hamatia elkneckensis* Pedersen *et al.* (1994) from the Albian of the Potomac Group, USA differs from *Platananthus* sp. in presence hook-like stamen connective, no delimitation among the apical extensions of connectives and anther thecae and less distinctly tricolporate pollen.

Aquia brookensis Crane *et al.* (1993) from the Albian of Virginia (USA) differs from *Platananthus* sp. in having longer filament and weakly developed apical extension of the connective. The number of stamens is not known.

Platanoid genera *Sarbaya* Krassilov et Shilin (1995) from the Cenomanian-Turonian of Kazakhstan and *Quadriplatanus* Magallón-Puebla *et al.* (1997) from the Coniacian-Santonian of Georgia, U.S.A. and unnamed staminate heads and flowers published by Crepet *et al.* (1992) and Crepet and Nixon (1996) from the Turonian of New Jersey (USA) differ from *Platananthus* sp. in number of stamens, having only four stamens per flower. *Sarbaya radiata* Krassilov et Shilin (1995) shows only limited characters for comparison. But, there are still some similarities to *Platananthus* sp., e.g. in the pollen morphology. *Quadriplatanus georgiana* Magallón-Puebla *et al.* (1997) differs from *Platananthus* sp. in having extensions of connectives weakly delimited from anther thecae and slightly different pollen morphology.

For overview and comparison with most Tertiary platanoid male reproductive structures I refer to Magallón-Puebla *et al.* (1997, Tab. 1).

ASSOCIATED LEAVES

"Platanus" laevis (Velenovský) Velenovský
Pl. 2

Credneria laevis Velenovský 1882, p. 13, pl. 3, fig. 4, pl. 4, figs. 2–6.
Platanus laevis (Velenovský) Velenovský 1889, p. 16, pl. 1, fig. 2.
Credneria purkynei Velenovský and Viniklář 1927, p. 19, 48, pl. 8, figs 5–8, pl. 12, fig. 7.
Platanus purkynei (Velenovský and Viniklář) Knobloch 1997, p. 139.

Description. The leaves occur in the same layer (unit 2 according to Uličný *et al.* 1997) of sandy mudstone lenses within fluvial sandstones. They are palmately lobed showing palinactinodromous venation (Pl. 2, figs. 1, 2), long petiole and exhibit a wide range of size variation (10–20 cm in length). They show usually 3, sometimes 4 lobes and narrowly cuneate base. The lobes have typically only few teeth.

Adaxial cuticle shows isodiametric ordinary cells (12 x 20 μm) and numerous trichome bases consisting of 4–5 cells. Abaxial cuticle shows isodiametric ordinary cells (25 x 30 μm) with sinuous anticlinal walls and broadly oval anomocytic stomata (20–28 μm across) with spindle-like outer pore (Pl. 2, fig. 3). Trichome bases appear to be of two kinds. Simple trichome bases with one circular basal cell are 25–30 μm in diameter. Multicellular trichome bases, which are particularly common on veins (Pl. 2, fig. 3), usually consist of 6–8 cells and are 35–40 μm in diameter.

Discussion. Platanoid leaves described herein from Pecínov are similar to the type material of *Platanus laevis* described by Velenovský (1882) from Central Bohemia (locality Mělník). Both leaves are typically trilobate. Knobloch (1997) assigned the leaves from the Pecínov locality to the species *Platanus purkynei* established by Velenovský and Viniklář (1927). *P. purkynei* differs from *P. laevis* in having sometimes four lobes per leaf instead only three. The single character based on lobation is of low taxonomic value and is herein interpreted as a possible variation within one species. Even more, both the type of *Platanus laevis* from Mělník and leaves from the Pecínov locality show the same type of stomata and trichome bases (Z. Kvaček 1983). Therefore they are considered to be conspeciphic, contrary to the opinion of Velenovský and Viniklář (1927) and Knobloch (1997).

It is suggested here to keep *Platanus laevis* in sense of Z. Kvaček (1983) for all typically trilobate platanoid leaves with delicately pronounced tertiary venation and epidermis showing fine undulation of anticlinal walls on abaxial leaf side, striated adaxial cuticle and frequent compound trichome bases.

Conclusions. Male inflorescences of *Platananthus* differ in crucial characters mentioned above from similar structures of the recent genus *Platanus*. The occurrence of *Platananthus* in association with leaves "*Platanus*" *laevis* showed the need of a new approach to systematics of platanoid foliage in the Late Cretaceous. This study reveals again the fact mentioned already by Maslova (oral communication 2002), that reproductive structures associated with Cretaceous *Platanus*-like leaves do not show characters identical with the recent genus *Platanus*. Therefore, it is recommended, the leaves of "*Platanus*" *laevis* traditionally assigned to the genus *Platanus* (Velenovský 1889) should be assigned to a distinct morpho-genus.

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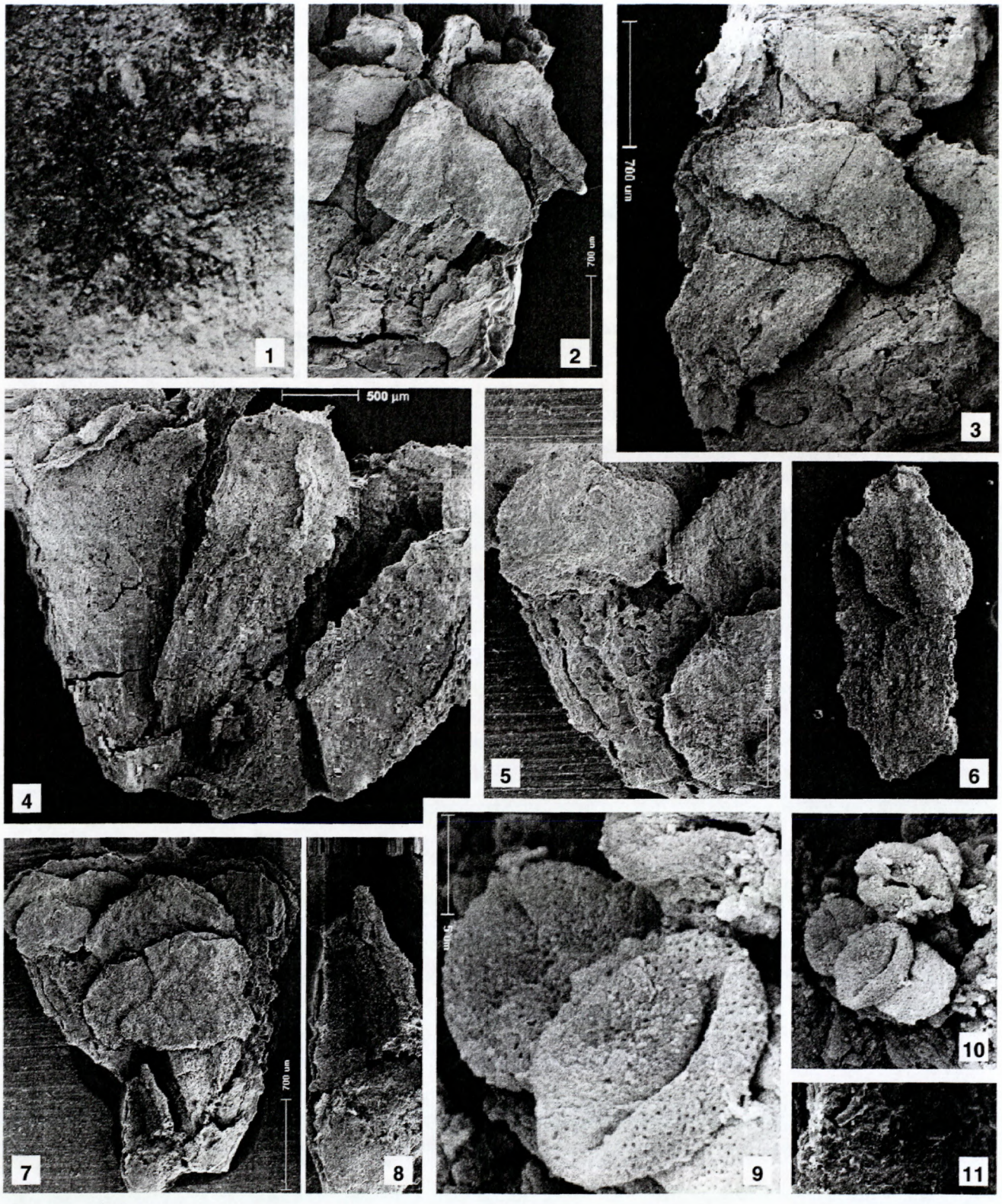


Plate 1

Platananthus **sp. F 2904, Pecínov, unit 2**

1 – Staminate inflorescence head (notice the adjacent head in the right corner of the picture), x 4; 2 – Isolated flower from top view showing unicycled androecium formed by five stamens, tepals are eroded, x 20; 3 – Flower in longitudinal section, showing two tepals and one stamen, x 30; 4 – Flower in longitudinal section showing three tepals (note the expanded apices), x 25; 5 – Incomplete flower with stamen showing apical extension of the connective and abraded anthers, detail of fig. 7, x 40; 6 – Isolated broken stamen showing abraded connective and anthers, x 40; 7 – Group of flowers showing broken stamens and tepals x 20; 8 – Detail of fig. 7, broken tepal x 60; 9 – Pollen grains in situ, detail of fig. 10, the colpi extend for most of the length of the pollen grain x 3400; 10 – Group of pollen grains *in situ* inside the stamen x 700; 11 – Corroded epidermis of tepal, detail of fig. 8, showing trichome base, x 250.





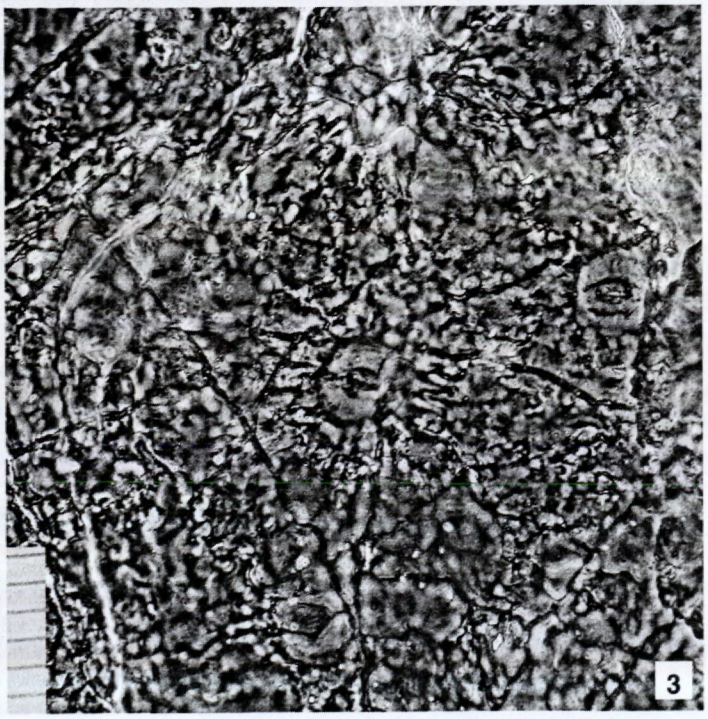


Plate 2
"Platanus" laevis **(Velenovský) Velenovský, Pecínov, unit 2**
1 – Trilobate leaf with long petiole, F 2867, x 1; 2 – Incompletely preserved trilobate leaf with well-preserved cuticle, F 2519, x 0.8; 3 – Cuticle showing anomocytic stomata and trichome base in phase contrast light, F 2519a, x 250.

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ACTUOECOLOGY OF THE LAKE THECAMOEBIANS FROM THE ŠUMAVA MOUNTAINS

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Abstract: At first this contribution explains the reason of the research and importance of thecamoebians including their utilisation in palaeoecology. Their fossil record is shortly summarised. The studied material comes from four lakes of the Šumava Mountains – "Čertovo jezero", "Černé jezero", "Plešné jezero" and water reservoir "Lipno", sampled several times in summer 2000. Seven thecamoebian species were found in these freshwater bodies. However, several important differences among these assemblages from various environments have been evidenced, namely differences in size distribution of the tests. For example, majority of test size in the "Plešné jezero" Lake varies from 125 μm to 140 μm, while the size of tests in the "Čertovo jezero" Lake is more disparate, ranging between 110 μm and 140 μm.

INTRODUCTION

The goal of the recent research is to evaluate important ecological factors influencing composition of the Recent thecamoebian assemblages, their biometrical variability and to determine the factors which could be applicable for reconstruction of environments in palaeoecology. Such a study will most probably make possible to use thecamoebians as fossils disposable to palaeoecological reconstruction of freshwater deposits. To achieve such goals it is necessary to study thecamoebian assemblages comming from various current environments within one large area and, as a second step, to analyse the samples. The Šumava Mts. represents very appropriate region for such a study, because of presence of numerous different freshwater bodies.

This study incorporates lake assemblages. Lakes "Černé jezero", "Čertovo jezero", "Plešné jezero" and water reservoir "Lipno" (Fig. 1) have been sampled and analysed several times. It closely links up another, similarly focused project, exploring several other freshwater bodies (Holcová and Lorencová 2001). Both projects were performed in a common extended area. Such kind of research is carried out for the first time.

POLYPHYLETIC GROUP – THECAMOEBIANS (TESTACEA)

Polyphyletic group of testate protozoans called "thecamoebians" has been studied. These organisms have amoeboid cell provided with pseudopods of three morphologic types: i) thin pointed, filose pseudopods, often with proximal branches, ii) finger-like lobose pseudopods, usually with rounded tips and iii) less common gently branching reticulose pseudopods forming a network. The next feature is the test. It could be autogenous (proteinaceous, siliceous or calcareous) or xenogenous (provided with a number of various agglutinated xenosomes, e.g. sand grains, diatom frustules or even wooden trash).

Morphology of the test and its composition are very important attributions applied in taxonomy. Both the mentioned attributions are used in palaeontology (e.g. when the soft parts are not preserved). Especially, the general shape of test is evaluated. There are two main types of the test established: i) beret shaped and ii) sack shaped forms. Several further features are used in systematics: morphology of spines and apertures of the test and detailes of the surface structure. Character and size of xenosomes are important for xenogenous tests. All these features differ in individual species but the type of the environment has certain effect too. In particular, the size of test is affected by ecological factors (Medioli *et al.* 1990).

Thecamoebians live mainly in fresh water and in hygric sites (for example in lakes, rivers, soils, peat bogs, mosses, marshes, on the bark, etc). Several species are able to live also in brackish water. They feed up on organic compounds, bacteria, fungi, algae or other protozoans. Their reproduction is asexual and it runs by binary fission. They are able to encyst, what is advantageous to survive under unfavourable conditions. The ability of encystation allows a wide distribution. The most important way of their transport is by wind and water birds. Thecamoebians are euryvalent and cosmopolitan organisms. However, the tolerance of species to different contamination in lakes is various (Patterson and Kumar 2000, Patterson *et. al.* 1996).

Taxonomy of the group is more or less questionable, as well as the determination of uniparental species (Loeblich and Tappan 1964, Ogden and Hedley 1980, Bartoš 1954, Medioli *et al.* 1990). In general, groups are usually distinguished on the basis of the test and pseudopods morphology (Fig. 2).

FOSSIL RECORD

The fossil record is sporadic, except in the Holocene. The oldest findings of thecamoebians come from the Namurian of the Czech Republic (Vašíček and Růžička 1957). Other

reports are known from Cretaceous – Greenland (Miner 1935), Alberta (McLean and Wall 1981, Medioli *et. al.* 1986) and Eocene – Colorado and Utah (Green River Formation – Bradley 1931). More findings have been done in Miocene deposits of Florida (Cushman 1930), Northern Patagonia (Frenguelli 1933), in Pannonian of Hungary (Kövári 1956), Slovakia (Brestenská 1977), and Poland (Kulczycka 1999). On the other hand, Holocene thecamoebians are frequent.

The rarity of the fossil record of thecamoebians is probably caused by limited ability of their tests to be preserved as fossils. Moreover, it is assumed that in various samples (for example palynological ones) many preserved thecamoebians are not identified and thus unreported.



Fig. 1. Map the of Czech Republic showing sampling sites – lakes "Černé jezero", "Čertovo jezero", "Plešné jezero" and water reservoir "Lipno" (cross shows localisation of sampling).

MATERIAL AND METHODS

The material comes from the Šumava Mountains. Lakes "Čertovo jezero", "Černé jezero", "Plešné jezero", "Prášilské jezero" and water reservoir "Lipno" have been sampled (Fig.1). Size of the lake, its trophic type, pH, depth, character of the bottom, vegetation and other ecological factors have been registered. Moreover, a lot of hydrological data could be used (Kopáček *et al.* 1998, 2001, Veselý 1994, Hejzlar *et al.* 2001, Majer *et al.* 2001, Kopáček *et al.* 2001). Harvests were carried out from the bottom, mostly from the water depth of 20–30 cm at the banks of the lakes. It was composed of sands with scarce organic detritus.

Fractions 0.5–0.036 mm have been used for the study of morphology, structures, chemical composition and size of the test (Medioli and Scott 1988). Tests have been measured by system of microvideo camera *Hirox KH 2200* (lens zoom 1–25) which transmit picture and Via video system (measuring unit *Boeckeler via 100*) with accuracy 5 %. Abundance of species is further recorded and then used for multivariate statistical analyses of the assemblage.

SYSTEMATICAL PART

Seven species have been found in the collected samples (Pl. 1).

According to Špinar (1960)

Regnum: Animalia
Phylum: Protozoa
Subphylum: Plasmodroma
Classis: Lobosa
Ordo: Thecamoebina lobosa (Testaceolobosia)
Subclassis: Filosa
Ordo: Theamoebina filosa (Testaceafilosa)
Subclassis: Granuloreticulosa
Ordo: Thalamia

According to Ogden & Hedley (1980)

Regnum: Animalia
Subregnum: Protozoa
Phylum: Sarcomastigophora
Subphylum: Sarcodina
Superclassis: Rhizopodea
Classis: Lobosia
Ordo: Arcellinida
Classis: Filosia
Ordo: Gromida

Fig. 2. Two different classifications of Thecamoebians.

Difflugia Leclerc in Lamarck, 1816
Type species: *Difflugia protaeiformis* Lamarck, 1816

Difflugia avellana Penard, 1890
Pl. 1, fig. 5

Description: The test is elongated oval slightly laterally compressed. The aperture is oval or circular. Test is covered with small agglutinated sand grains. The smallest particles surround the aperture.

Occurrence: "Čertovo jezero" Lake.

Difflugia globulosa Dujardin, 1837
Pl. 1, fig. 7

Description: The test is spherical or hemispherical. The aperture is circular. Test is covered with small agglutinated sand grains. The smallest particles surround the aperture.

Occurrence: "Čertovo jezero", "Plešné jezero" lakes, "Lipno" Reservoir.

Centropyxis Stein, 1859
Type species: *Arcella aculeata* Ehrenberg, 1832

Centropyxis sp.
Pl. 1, fig. 2

Description: The test is brown, circular in horizontal view and hemispherical in lateral view. Aperture is central and slightly invaginated widely oval.

Occurrence: "Plešné jezero" Lake

Remarks: Specimens are not good preserved. The shape and the margin of the aperture is not distinct and that is why it is impossible to determine it exactly.

Centropyxis constricta Ehrenberg, 1838
Pl. 1, fig. 4

Description: The test is yellow or brown and ovoid in horizontal view. It is slightly compressed in lateral view towards the aperture. The aperture is invaginated, circular or oval. It is situated eccentrically.

Occurrence: "Lipno" Reservoir

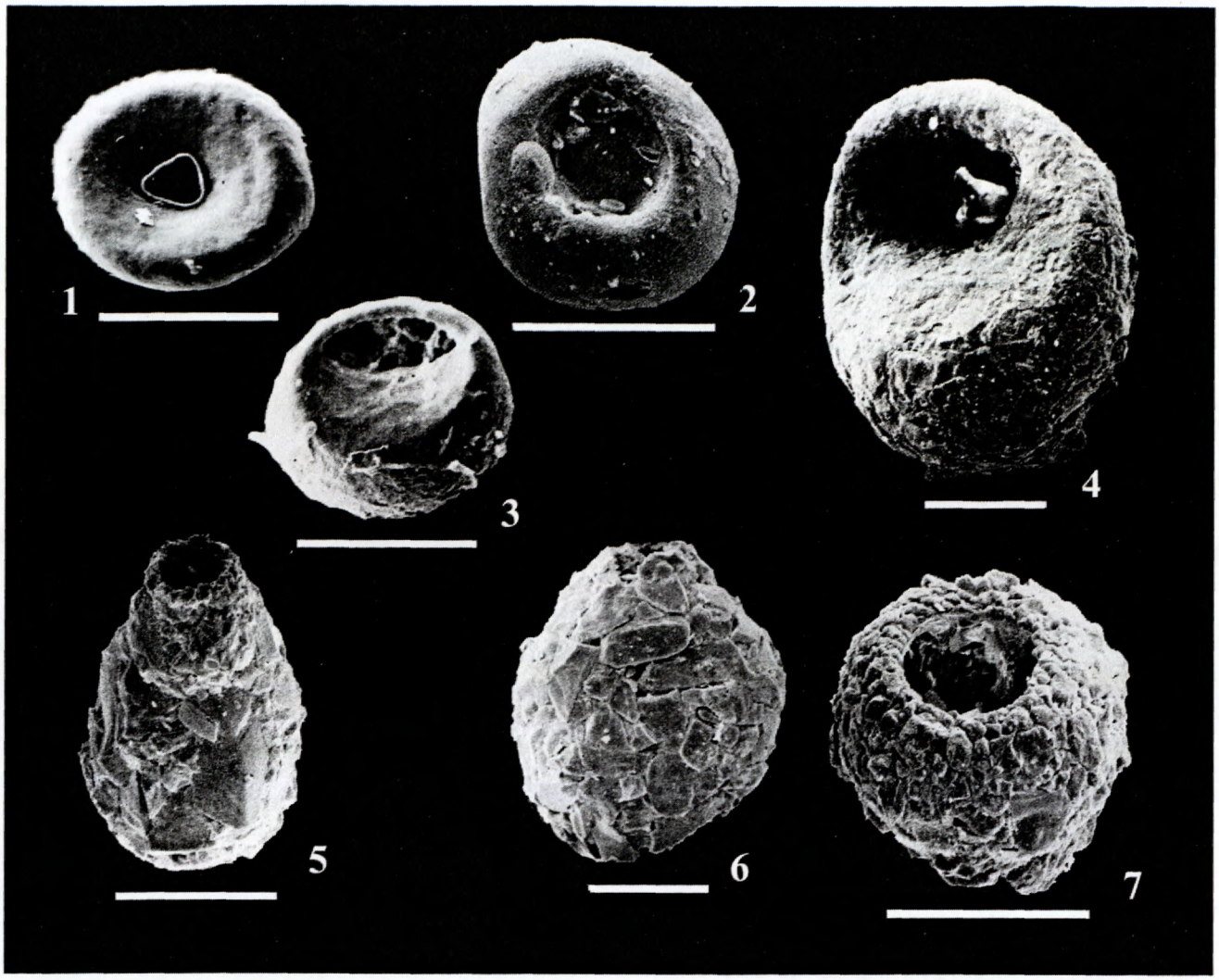


Plate 1
Length of the scale bar is 50 cm.
1 – *Trigonopyxis arcula* (Leidy 1879), "Prášilské jezero" Lake, 2 – *Centropyxis* sp., "Plešné jezero" Lake, initiation of encystation, 3 – *Centropyxis ecornis* Ehrenberg, 1838, "Čertovo jezero" Lake, 4 – *Centropyxis constricta* Ehrenberg, 1838, "Lipno" Reservoir, 5 – *Difflugia avellana* Penard, 1890, "Čertovo jezero" Lake, 6 – *Nebela* sp., "Čertovo jezero" Lake, 7 – *Difflugia globulosa* Dujardin, 1837, "Čertovo jezero" Lake.

Centropyxis ecornis Ehrenberg, 1838
Pl. 1, fig. 3

Description: The test is brown, circular in horizontal view and hemispherical in lateral view. The test is compressed mainly above the aperture. Aperture is on the ventral side and it is eccentric. It is invaginated and widely elliptic.

Occurrence: "Čertovo jezero" Lake

Nebela Leidy, 1874
Type species: *Difflugia (Nebela) numata* Leidy, 1875

Nebela sp.
Pl. 1, fig. 6

Description: The test is widely ovoid. The surface is covered with different sizes of sand-grains. Aperture is oval.

Occurrence: "Čertovo jezero" Lake

Remarks: This species is presented only by two specimens in the sample and moreover, they are not good preserved to determine them exactly. The shape of the test is distinct and that is why these individuals are determine as *Nebela* sp.

Trigonopyxis Penard, 1912
Type species: *Difflugia arcula* Leidy, 1879

Trigonopyxis arcula (Leidy, 1879)
Pl. 1, fig. 1

Description: The test is yellow or brown, circular in horizontal view and hemispherical in lateral view. The apertural surface is slightly invaginated. The aperture is in the middle of this side. It is triangular and surrounded by a small collar.

Occurrence: "Lipno" Reservoir

BIOMETRICAL ANALYSIS

Tests of *Difflugia globulosa* and their cysts (populations from lakes "Čertovo jezero" and "Plešné jezero") were measured by via video system (Pl. 1, fig. 7). In all, 282 specimens have been measured (163 specimens from the "Plešné jezero" Lake and 119 specimens from the "Čertovo jezero" Lake – 65 and 54 specimens from two different points).

There exist some differences among the assemblages originating from various environments. For example, majority of test sizes in the "Plešné jezero" Lake varies from 125 μm to 140 μm, while test sizes in the "Čertovo jezero" Lake are more disparate, ranging between 110 μm and 140 μm. Size distribution is in both cases nearly continuous with 1 or 2 maxima (Fig. 3).

Compositions of the whole thecamoebian assemblage diverge, too. *Difflugia globulosa* (95%) is the most abundant species in the "Plešné jezero" Lake. The second common species is *Centropyxis* div. sp. (5%). *Difflugia globulosa* (96%) dominates also in the assemblage of the first sample from the "Čertovo jezero" Lake. The other present species are *Nebela* sp. and *Difflugia avellana* (4%). In the second collecting sample from another point of this lake, *Difflugia globulosa* is also the most numerous (75%). *Nebela* sp. and *Difflugia avellana* compose the less abundant morphological group (24%). *Centropyxis* div. sp. is the less present species (1%).

CONCLUSIONS

Seven thecamoebian species have been determined in four oligotrophic lakes in the Šumava Mts. Spherical forms (*Difflugia globulosa* Dujardin, 1837) and their cysts are dominating (75%–95%). Size distribution is nearly continuous with 1 or 2 maxima, which differ in various lakes.

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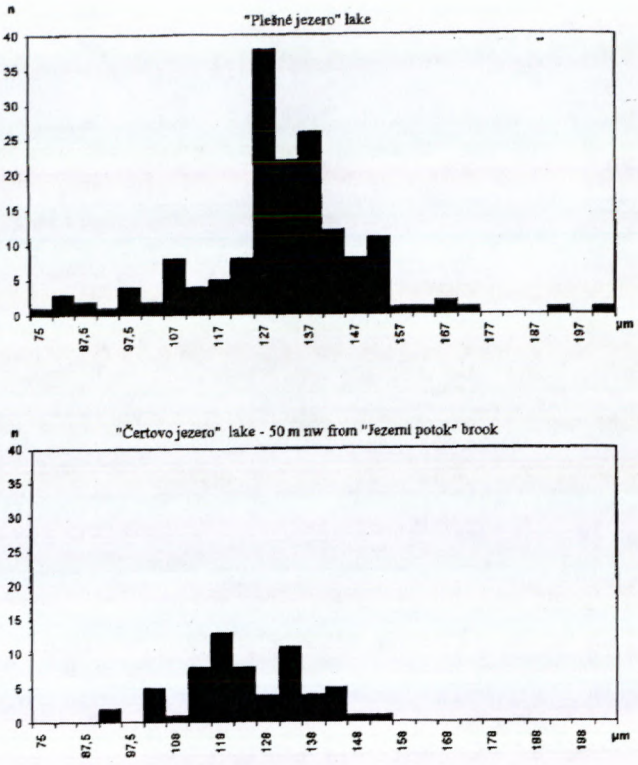


Fig. 3. Histograms of the test sizes of the thecamoebians spherical forms from one locality of the "Čertovo jezero" and the "Plešné jezero" lakes.

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BIOTURBATION OF CLAYSTONES OF THE MOST BASIN IN THE BÍLINA QUARRY (MIOCENE, CZECH REPUBLIC)

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Abstract: In the Miocene of the Most Basin, tuffitic substrates underlying the Main Coal Seam yielded the trace fossil *Taenidium* isp. The body of lacustrine clays above the Main Coal Seam contains frequent ? *Selenichnites* isp. The persistent horizon of dark clay provided finds of *Unisulcus*. A substantial part of the mudstone deposits of the Bílina delta shows a well-visible, intensive bioturbation by *Planolites montanus*. Finds of *Taenidium* isp. point to the settings of periodically inundated paleosols. ?*Selenichnites* isp. occurs in quiet, shallow-water lacustrine settings. The same regime could be characteristic for *Unisulcus*-dominated sediment, with perhaps stronger ecological stress for most of the benthic fauna. The *Planolites montanus* assemblage had been cyclically suppressed by rapid sedimentation and subsequent biological influence. It is likely that the periodicity of the cycle was very short, probably annual.

INTRODUCTION

Before 1980s', the study of trace fossils was limited mostly to descriptions of clearly discernible, isolated traces of invertebrates from marine sediments, or vertebrate footprints from various settings. Later, a considerable attention was paid to ichnofossils in nonmarine, especially coal-bearing sequences (e.g., Archer and Maples 1984; Miller and Knox 1985; Eagar *et al.* 1985; Pollard 1986, 1988). The growing effort in the ichnological study of continental settings recently enabled to assess ichnologic record of the continental invertebrate invasion, its evolutionary trends, ecospace utilization, and behavioural complexity (Buatois *et al.* 1998).

At the same time, the methods of study of intensively bioturbated rocks, involving time and space relationships between individual components of bioturbation and widely using core material and vertical stratigraphic sections, developed into the so-called ichnofabric analysis (e.g., Ekdale and Bromley 1983; Taylor and Goldring 1993).

In the Miocene of the Most Basin, three distinct patterns of bioturbation have been found in the relatively thick sequence of mudstones and sandy mudstones overlying the Main Coal Seam. A different style of bioturbation is displayed in the tuffaceous substrate underlying the seam. Bioturbation often represents (besides morphologically poorly defined coprolites and plant detritus) the only macropalaeontological record. The aim of this contribution is to describe and interpret this bioturbation using systematic ichnology, ichnofabric analysis and sedimentological and palaeogeographical aspects.

GEOLOGICAL SETTING

The Most Basin is one of the four major sedimentary basins preserved in the Ohře Graben and separated from one another by volcanic domains any by fault systems which cross-cut the Ohře Graben at high angles (Rajchl and Uličný 2001). In the vicinity of Bílina, the fill of the basin overlies Upper Cretaceous marls and starts with the Oligocene tuffs, volcanic breccias and their weathering products, proluvial and colluvial deposits, allochthonous coal seams, coal clays, lacustrine clays, and autochthonous coal seams (e.g., Mach and Rajchl 2001; Fig. 1). Units overlying the main seam belong to the so-called Bílina delta (e.g., Rajchl and Uličný 2001). The delta formed at the mouth of a river that drained into a fairly shallow lake (not more than several metres deep), which formed on a subsiding mire and was surrounded by peat-bogs during most of the time of deltaic sedimentation (Mach and Dvořák 1999). Wedge-shaped and lenticular bodies of the delta sediments, interfering with the surrounding sheet-like bodies of lacustrine clays, characterized the basic depositional pattern of the fluvio-deltaic system. The delta is interpreted as a fluvial--dominated, mouth-bar type (or "birdfoot" delta, with distributaries terminated by friction-dominated mouth-bars (Rajchl and Uličný 2001).

This sequence bears four ichnoassemblages, each of them dominated by one ichnotaxon. Tuffitic substrates underlying the main coal seam ca. 300-m of the present western margin of the quarry yielded *Taenidium* isp. The body of lacustrine clays above the Main Coal Seam, developed in the thickness of 45 m in the mid-western part of the quarry, contains frequent ? *Selenichnites* isp. The persistent horizon of dark lacustrine clay approx. 10–40 m above the seam provided finds of *Unisulcus*. A substantial part of the mudstone deposits of the Bílina delta shows a well-visible, intensive bioturbation by *Planolites montanus* (Fig. 1). This type of bioturbation was preliminarily described and interpreted by Mikuláš (1998).

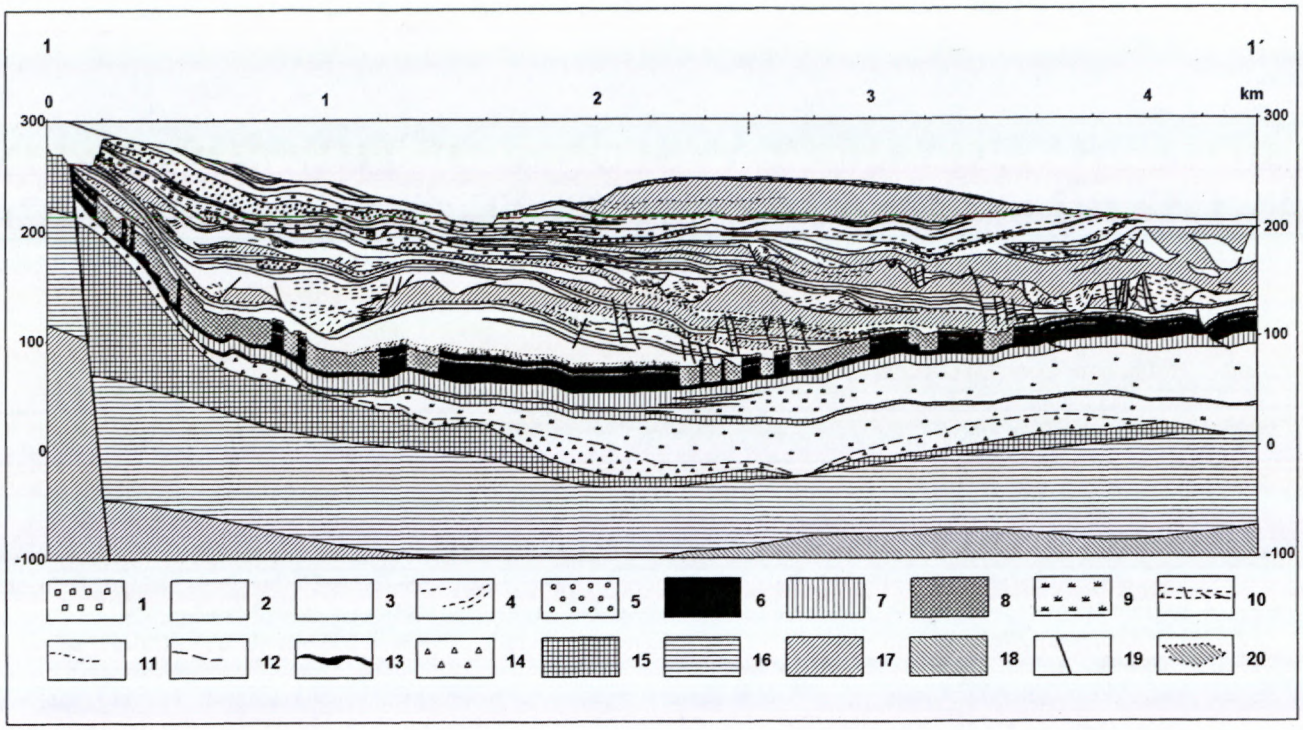


Fig. 1. Geological cross-section of the study area in the Bílina opencast mine. 1. Quaternary: loess, sands and gravels, 2– 13. Miocene: 2. lacustrine and pro-deltaic clays, 3. dark lacustrine clays, 4. clayey-sandy accumulationf of delta lobes, 5. channel deposits, 6. coal seam – coal, 7. coal seam – dirty coal, carbonaceous clays, 8. extracted coal seam, 9. delta-plain and flood plain deposits, 10. stump horizon, 11. thin beds of coal and carbonaceous clay, 12. significant blackband horizons 13. allochthonous coal seams, 14. proluvial – colluvial deposits, 15. Střezov Formation (Oligocene): basalts, phonolites, tuffs, volcanic breccias and their weathering products, 16. Cretaceous: marls, 17. Carboniferous-rhyolite, 18. Proterozoic: gneiss, 19. faults, 20. extent of ichnofossils (domichnia).

SYSTEMATIC ICHNOLOGY

Planolites Nicholson, 1873

?*Planolites* cf. *P. montanus* (Richter, 1938)
Pl. I, figs. 1–3; Pl. II, figs. 5, 6

Material: Numerous field observations and the archived core material from the above-specified interval (housed in the material documentation of the Doly Bílina, a.s.). About 20 samples collected for laboratory study and housed in the collection of R. Mikuláš in the Institute of Geology, Academy of Sciences of the Czech Republic.

Description: Thin, irregularly branching, usually moderately curved tunnels, showing both subhorizontal and oblique to vertical sections. Individual tunnels show slight fluctuations of their diameter (which ranges from 0.7 to 1.5 mm). Wall of the tunnels is unlined, unsculptured; fill is passive, homogeneous, apparently composed of material identical with the lamina overlying the opening. The traces normally occupy 10–30% of the host rock; some light layers, however, seem to be bioturbated almost 100% but they do not show the morphology of the bioturbation clearly. Some horizontally orientated polished sections show mostly circular cross-sections of the traces, resembling the cross-sections of "pipe rocks", while other show a more-or-less balanced proportion of cross-sections of vertical and subhorizontal components, or even prevalence of subhorizontal components. This fact points to a vertical inhomogeneity of the bioturbation well visible on many vertically orientated polished sections. Some of the horizontally orientated polished sections suggest roughly radial orientations of the tunnels.

Remarks: Evaluation of the described traces following the criteria of systematic ichnology is difficult, as in many other cases of morphologically simple ichnofossils. As there is no regular way of branching of the tunnels, the trace cannot be attributed to *Chondrites* Sternberg, 1833 (see Fu 1991 for details on morphology and ethology of the ichnogenus). Similar traces have been placed by many authors to the ichnospecies *Planolites montanus* (Richter 1933) (see Pemberton and Frey 1982). However, the features of our material, such as the uneven diameter of the tunnels (which may be partly caused by subsequent deformation) or the imperfectly but evidently developed vertical structuration of the tunnel systems, allows us to place the described traces to this ichnotaxon with some reservation only.

Ethologically, the traces can be understood as fodinichnia (i.e., traces of feeding on the sediment), domichnia (dwelling burrows) or utility structures, e.g. places of "farming" bacteria for subsequent feeding (see, e.g., Bromley 1996 for further explanation of these ethological categories). The uneven diameter of the tunnels suggests that they do not represent individual feeding probes, therefore, the dwelling, or combined dwelling--feeding-utility function would better correspond to their morphology.

Some of the tunnels also provided plant detritus in their fill, which suggested their origin by plant roots or pertinence to plant body fossils. Root systems may show similar morphologies (e.g., Bockelie 1994, Retallack 1990).

Moreover, Obrhel (1964) described dense populations of fossil liver-wort *Riccia* cf. *fluitans* from the Cheb and Sokolov basins (Tertiary, western Bohemia), which show a surprising morphological similarity to the described traces. However, the plant detritus in the fill of the tunnels appeared to be very heterogeneous which confirms the assumption on the animal origin of the tunnels.

Very similar bioturbation was described and figured by Pollard (1988; Fig. 2b) from the Carboniferous (Westphalian A) at Lancashire under the name *Planolites montanus* (Richter). Pollard (op. cit.), evaluating the data of several other authors, concluded that the *Planolites montanus* bioturbation is most common in flood basin lake sediments.

Selenichnites Hardy, 1970

? *Selenichnites* isp.
Pl. II, figs. 1–3

Material: Dozens of field observations and about 10 rock samples having numerous traces collected for laboratory study (housed in the material documentation of the Doly Bílina, a.s.).

Description: Shallow, roughly circular to crescent-like casts (convex hyporeliefs or concave epireliefs). Surface is smooth, fill passive, laminated. Diameter 10–20 mm. The traces usually occur in high amounts in the above specified part of the sequence, occupying 5–20 % of the rock volume. If irregular or crescent-like, they are orientated in one direction.

Remarks: These traces resemble the ichnospecies *Selenichnites rossendalensis* Hardy, 1970, by basically horseshoe to crescent-like shape and by a prominent (?current-controlled) preferred orientation of specimens preserved on the same bedding plane. However, no morphological details which would be helpful for the identification of the tracemaker are present. Therefore, the trace has to be compared also to smooth, plug-shaped traces such as *Bergaueria* Prantl or *Piscichnus* Feibel. All the above-mentioned traces bear typical features of the ethological group of cubichnia (i.e., resting traces). Small fish, tadpoles (cf. Uchman 2000) or crustaceans are the possible tracemakers in the freshwater Miocene deposits.

Taenidium Heer, 1877

Taenidium isp.
Pl. I, figs. 5–6

Material: Two collected samples bearing a dozen of finds (full reliefs) from the above specified sequence in the Bílina Quarry.

Description: Cylindrical, straight to slightly curved, non-ramifying, usually oblique tunnels, showing a regular, fine meniscate filling. Diameter 2–6 mm, length of preserved parts several centimetres. Wall lining is not present.

Remarks: Using the conclusions of D'Alessandro and Bromley (1987) and later authors, these traces correspond to *Taenidium* Heer. They represent actively filled traces of sediment feeders. In terrestrial context, these traces are considered characteristic for paleosols (e.g., Genise et al. 2001).

Unisulcus Hitchcock, 1858

?*Unisulcus* cf. *U. minutus* Hitchcock, 1858
Pl. I, fig. 4

Material: Numerous field observations from the above specified sequence. Two samples collected for laboratory study and housed in the collection of R. Mikuláš in the Institute of Geology, Academy of Sciences of the Czech Republic.

Description: Horizontal, curved to winding, smooth, very shallow, poorly observable, fine surface trails (grooves or burrows). Width less than 1 mm. These traces are observable on fresh material when the contrast between their fill and the substrate is augmented by capillary water. After drying of the sediment, the rock seems unbioturbated, showing even virtually undisturbed lamination.

Remarks: *Unisulcus* and similar traces (e.g., *Mermia*, *Helminthopis*; cf. Buatios et al. 1999) can be interpreted as feeding and locomotion traces of minute benthic "worm-like" fauna.

ICHNOFABRIC ANALYSIS

A systematic description of individually recognizable morphological patterns of traces (i.e., of individual ichnotaxa) provides little information about their time and space relationships. To evaluate this important factor of bioturbation, the ichnofabric analysis has been introduced (Ekdale and Bromley 1983, Pollard et al. 1993, Taylor and Goldring 1993). The ichnofabric time sequence diagrams are helpful especially when a number of ichnotaxa occur in one layer, involving numerous cross-sections of them, or even almost complete destruction of the previous "generation" of the bioturbation by the subsequent one. This is not the case of the described bioturbation, where only one morphological type is present.

Nevertheless, for the described occurrence of *Planolites montanus*, the ichnofabric time sequence diagram (Fig. 2) shows well the vertical stratification of the bioturbation, i.e. the cyclicity of its appearance. Less traditionally, several distinct beds are shown on the picture of the characterized ichnofabric to document its rhythmical occurrence also quantitatively.

The function of the light, mottled laminae is not very clear. They appear to be fully bioturbated, but the colour contrast of this bioturbation is vague; therefore, the morphological analysis of the bioturbation is nearly impossible. This, however, does not argue against the apparent cyclicity of the bioturbation pattern, showing the vertical distance of the individual "generations" of usually 5–15 mm.

CONCLUSIONS

For the palaeogeographical and sedimentological evaluation of the described bioturbation, two points are

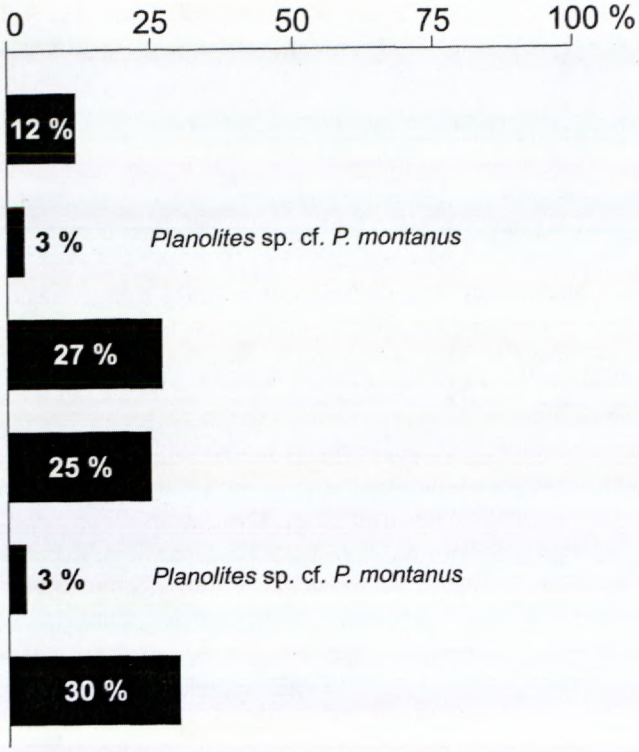


Fig. 2. Ichnofabric time sequence diagram of the representative vertical section of the Planolites montanus Ichnofabric (cf. Pl. I, fig. 3). The percentage means the overall percentage of all the depicted section, not the share of ichnofossil fillings in the surrounding rock.

important: 1, empirical comparison of the described bioturbation with similar occurrences and their presumed environments, and 2, time characteristics of the rhythmicity of the bioturbation.

For *Taenidium* isp., its occurrences described in the Cenozoic of the South America come from periodically inundated paleosols (Genise et al. 2001).

?*Selenichnites* isp., interpreted as cubichnia of small fish or amphibian larvae, generally occurs in quiet, very shallow-water lacustrine settings comparable with the present artificial reservoirs of the České Budějovice or Třeboň basins in southern Bohemia. The lack of traces of in-fauna points to the deficit of oxygen in the sediment. The same regime could be characteristic for the *Unisulcus*-dominated sediment, with perhaps even stronger ecological stress for most of the benthic fauna.

Planolites montanus bioturbation was described by Pollard (1988) who concluded that it should be characteristic for flood basin lake environment, but a similar picture of bioturbation may appear in other settings, especially crevasse splays, brackish lagoons, and tidal flats.

Spatial distribution of the described bioturbation shows a persistence of a simple, very probably invertebrate in-faunal assemblage for the whole time of the deposition of the above described mudstone body. This assemblage was cyclically suppressed by rapid sedimentation, and possibly also by temperature fluctuations and subsequent biological influence (e.g., fluctuation of food sources). If the period between the populations had been long (e.g., hundreds of years), the limited space of the basin would have been very unlikely to allow so regular and rapid colonization of the niche every time when suitable conditions occurred. For this reason, it is likely that the periodicity of the cycle was very short, probably annual.

In conclusion, a very rapid sedimentation of the mudstone body is presumed (roughly 1 m per 1,000 years).

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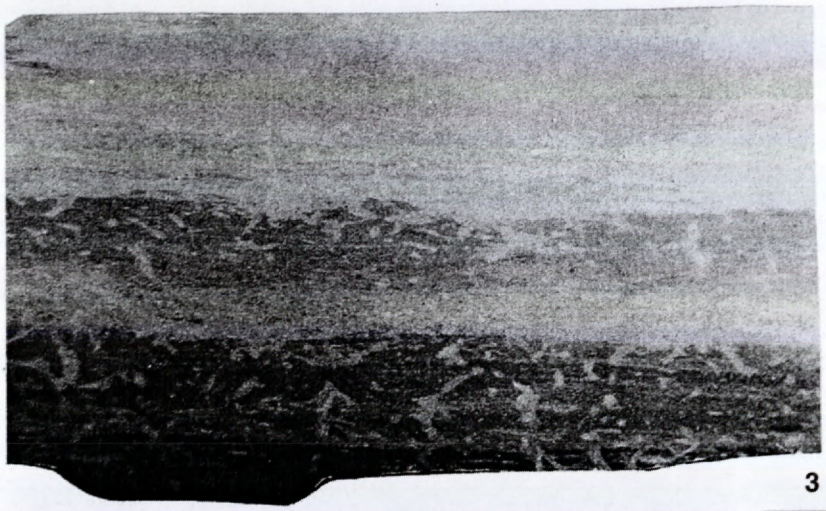
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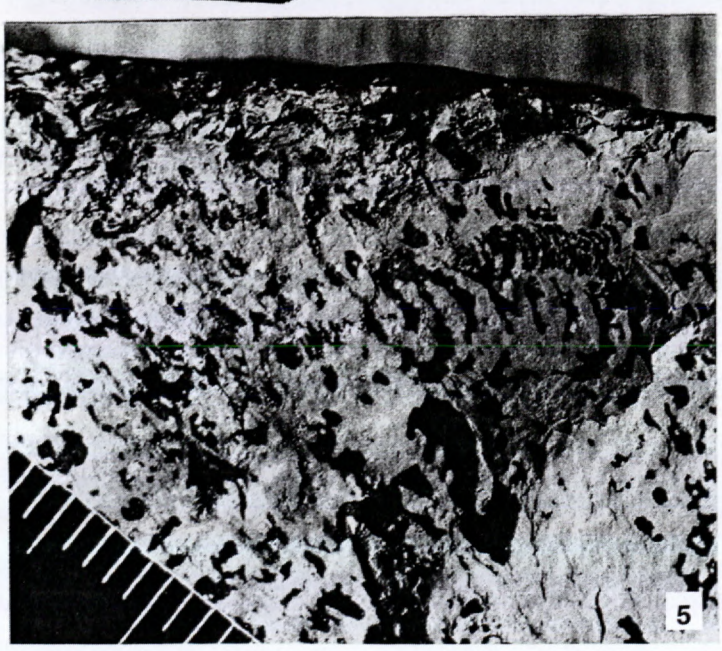




Plate I

1–3 – ?*Planolites* cf. *P. montanus* (Richter, 1938). 4 – ?*Unisulcus* cf. *U. minutus* Hitchcock, 1858. 5–6 – *Taenidium* isp. Enlargements: 1 – x 1.8; 2 – x 2.5; 3 – x 1.3; 4 – x 3.0, 5–6: scale in millimetres. Miocene, Bílina Quarry, housed in the material documentation of the Doly Bilina, a.s.

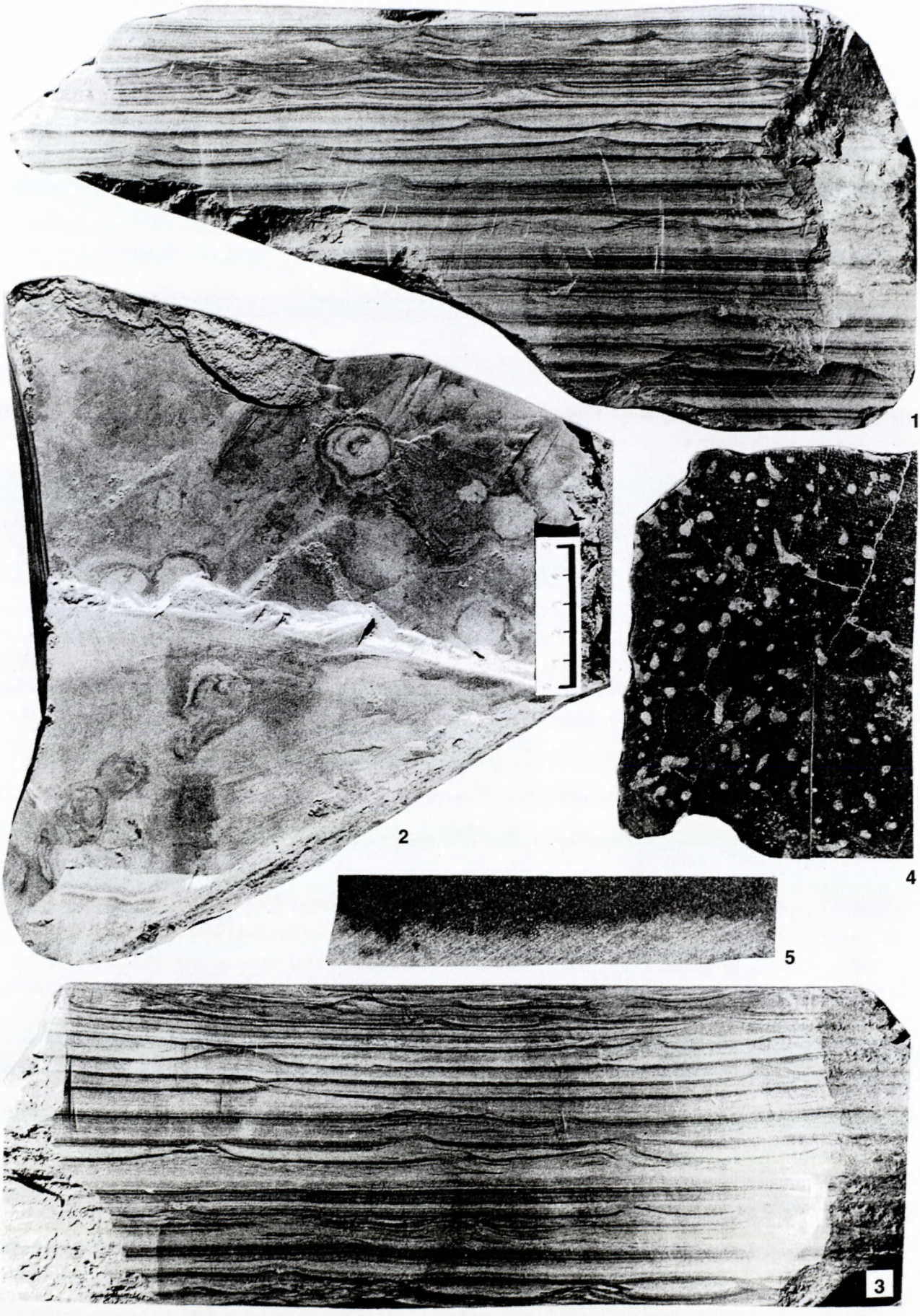


Plate II

1–3 – ? *Selenichnites* isp. 4–6 – ?*Planolites* cf. *P. montanus* (Richter, 1938). Enlargements: 1 – x 0.7; 2 – x 0.5; 3 – x 0.7; 4 – x 3.0, 5 – x 1.5. Miocene, Bílina Quarry, housed in the material documentation of the Doly Bilina, a.s.

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TROGONTHERIUM CUVIERI FISCHER, 1809 (RODENTIA, MAMMALIA) IM MITTELBÖHMISCHEN PLEISTOZÄN

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Kurzfassung: Die Gattung *Trogontherium* Fischer, 1809 (Rodentia, Castoroidea) war der größte Vertreter der Biberartigen Nagetiere in Eurasien in der Zeitsspanne vom Miozän bis Pleistozän d. h. während der Biozonen MN 4 – MQ 1. In Böhmen stammen die Befunde aus drei Fundorten: aus den Höhlen bzw. Höhlenruinen Chlum I. und Chlum IV. und den fluviolimnischen Schichten in Přezletice.

EINLEITUNG

Trogontherium cuvieri (Fischer, 1809) ist der größte Vertreter der bieberartigen Nager, Angehöriger der Oberfamilie Castoroidea in der Unterordnung Sciuromorpha. Phylogenie dieser Gruppe ist nicht eindeutig; Matthew (im Thenius 1972) leitet die Familie Castoridae von den paläogenen Nagern Ischyromyidae, Wood (1955) von den primitiven Paramyidae, unabhängig von der Oberfamilie Sciuroidea ab.

In die Oberfamilie Castoroidea gehören zwei Familien:

1. Castoridae Gray, 1821 (oberes Eozän in Nordamerika, unteres Oligozän in Europa und Asia bis Recent). Die occlusalen Bilder sind relativ sehr einfach. Die Bäckenzähne sind progressiv hypsodont und die Prämolaren größer als die Molaren.

2. Eutypomyidae Miller und Gidley, 1918 (Eozän bis Miozän Nordamerika, in Europa unbekannt). Hier sind die oberen Zähnreihen parallel und Prämolaren und Molaren haben ähnliche Occlusalbilder und gleiche Größe. Die Bäckenzähne sind niederkronig.

Die Familie der eigentlichen Bibern – Castoridae – kommt erstmal im oberen Eozän Nordamerikas mit *Agnotocastor* Stirton, 1935 vor. Stirton unterscheidet drei selbständige paläogeographische Regionen der Bieberentwicklung und unterstützt die polyphyletische Herkunft der ganzen Gruppe, obwohl die Bieberformen der einzelnen Entwicklungslinien einander ähnlich sind (Hugueney 1999). Erst im Pliozän und Pleistozän kommen größere Formen vor. In Nordamerika war es die Gattung *Castoroides* Foster, 1838 und in Europa *Trogontherium* Fischer, 1809. *Castoroides ohioensis* Stirton, 1935 erreicht die Größe des rezenten Bären und *Trogontherium cuvieri* Fischer, 1809 des Wolfes. Phylogenetisch steht die Gattung *Trogontherium* näher dem *Castor* als *Castoroides*.

Auf dem Gebiet der ehemaligen Tschechoslowakei wurden folgende Arten beschrieben: 1. Aus dem jungpliozänen Villányium: *Trogontherium minus* Newton, 1890 (MN 16a) von Hajnáčka in der Slowakei (Fejfar 1961, 1964; Fejfar, Heinrich 1985; Fejfar, Heinrich, Heintz 1990) und 2. aus dem altpleistozänen Biharium: *Trogontherium cuvieri* Fischer, 1809 aus den Höhlen/Höhlenruinen Chlum I. und IV. (Petrbok 1938, 1941) und aus Přezletice (Zázvorka 1938, Fejfar 1993).

Trogontherium cuvieri F. war vom Oberpliozän bis Ende des Pleistozän in Europa und Asien zusammen mit *Castor* verbreitet. Die beiden Formen unterscheiden sich in den Merkmalen am Skelet, z. B. am Schädel und femur (Schreuder 1929, 1951). Die Schädelreste waren im studierten Material meistens als Fragmente vertreten. Die vorliegende Arbeit befasst sich daher die mit den Zahnresten.

DIE FUNDORTE

Das Material stammt aus drei Fundorten.

Zwei Fundorte Chlum I. und Chlum IV. befinden sich im verlassenem Steinbruch bei Srbsko, im Gebiet des böhmischen Paläozoikum sw. von Prag (Barrandien). Es handelt sich um Reste der altpleistozänen Höhlenablagerungen bzw. Spaltenfüllungen, etwa 4 km südwestlich von der Stadt Beroun und nördlich von der Ortschaft Srbsko im Tal des Flusses Berounka. Das System der Höhlen und Karstspalten – der sog. „Höhlen von Srbsko" – ist in den Lochkov- und Koněprusy-Kalken (Pragium, Unterdevon) entstanden, und wurde durch den umfangreichen Steinbrüche aufeinanderfolgend freigelegt (Chlupáč 2003). Das Niveau der biharischen Verkarstung entspricht etwa der III. Terrasse des Flusses. Die Höhle Chlum I. wurde 1938 endeckt und später durch den Betrieb des Steinbruchs abgebaut. Sie war mit gelben pleistozänen Lehmen ausgefüllt (Petrbok 1941). Die Höhle Chlum IV. wurde im nordwestlichen Teil der unteren Etage 1941 freigelegt. Sie hatte Form einer schrägen, kaminartigen Korrosionshöhlung und verlief entlang einer tektonichen Linie bis an die Oberfläche. Die Sedimente bildeten von oben nach unten: folgende Abfolge: Sand, lockere Sinterschicht (die Fundschicht der Fauna), schwarzer

Manganlehm, neogene weisse Tone. Die Fauna (Fejfar 1961; Horáček 1979) repräsentiert die Nagyhársányhegy Phase des späteren Biharium (Kretzoi 1956). In beiden Faunen ist gemeinsames Vorkommen von *T. cuvieri* F. und viel reichlicher *Castor fiber* LINNE.

Der dritte Fundort Přezletice – Hügel Zlatý kopec (248 m ü. M.) befindet sich im verlassenenen Steinbruch (proterozoische Schiefer und Lydite) am nordöstlichen Rand von Prag. Die Knochenreste stammen aus den fluvio-limnischen Lagen (kalkhaltige Mergel und tonige Sande) innerhalb einer hohen Terrasse von Elbe. Die Flussterrasse gehört in den Bereich der altpleistozänen höheren Elbe-Terassen; diese Terrasse gehört zu dem Cromer- (Günz/Mindel-) Interglazial oder der Wärmeperiode der nachfolgenden Elster-Eiszeit (Šibrava *et al.* 1979), bzw. innerhalb der Akkumulation von Pankrác und Suchdol Terassen der Moldau-Terassensysteme (Záruba *et al.* 1977). Die Fauna (Šibrava *et al.* 1979; Fejfar 1993) repräsentiert die Säugetierstufe Biharium, die Säugetier--Phase Templomhegy (Kretzoi 1956; Zázvorka 1938, Fejfar 1993). Aus diesem Fundort kennen wir nur sporadische Befunde den Gattung *Trogontherium.* Die Gattung *Castor* war hier nicht gefunden.

DIE BESCHREIBUNG

Rodentia
Castoroidea GILL,1872
Castoridae GRAY, 1821
Castoroidinea TROUSSART, 1880
(Castoroididae ALLEN, 1877)
Trogontherium FISCHER, 1809
Trogontherium cuvieri FISCHER, 1809
(Abb. 1, 2)

Material: 5 Schneidenzähnefragmente, 8 Prämolaren, 7 Molaren, 2 Unterkiefer und 1 Oberkiefer (Tab. 1). Alle Fragmente der Inzisiven sind pigmentiert und haben an der Schmelzoberfläche die typischen Längstleisten. Aufbewahrt in den Sammlungen des Národní Museum, Praha. Chlum I. Höhle – Ra 2622 (I sup. sin.), Ra 2623 (I inf. dext.), Ra 2624 (I inf. sin.), Ra 2625 (P4 sup. dext.), Ra 2626 (P4 sup. dext.), Ra 2627 (P4 sup. sin.), Ra 2628 (M3 sup. dext.); Chlum IV. Höhle – R 5972 (P4 sup. sin.), R 5973 (p4 inf. sin.), R 5732 (p4 inf. sin.), R 5733 (der rechte UK-fragment mit p–4–m1 und mittlerem Teil von Schneidenzahn), R 2035 (der linke UK-fragment mit p–4–m1 und mittlerem Teil vom Schneidenzahn); Přezletice R 3959 (M1 sup. dext.), R 3960 (der linke OK mit M1–M3).

Die Beschreibung: Die Gattung *Trogontherium* hat wie alle Castoroidea relativ einfache Zahnformel 1013/1013. Sie unterscheidet sich von *Castor* im transversalen Querschnitt und in der Schmelzoberfläche der Schneidenzähne, im Grade der Molarenhöhe im allgemeinen Gestalt der Zähne und ihrer Occlusalbilder. Die Art *Trogontherium cuvieri* F. hat den abgerundeten Querschnitt der Schneidenzähne und die Labialfläche ist konvex (Stirton 1935). Der Zahnschmelz ist orangefärbig pigmentiert, hat eine oberflächliche Struktur der „Orangenschale" und seichte längliche Leisten. Wie bei allen Vertretern der Castoroidea bilden die Backenzähne einen Prämolar (p/P 4) und drei Molaren m/M

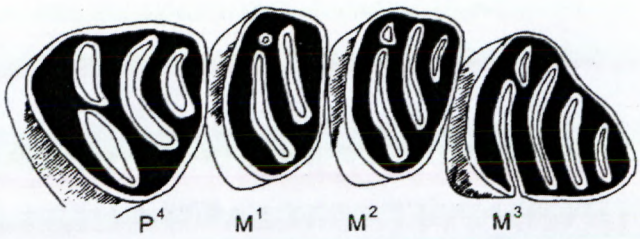


Abb. 1

1–3 (Abb. 1.); die Prämolaren sind stark molarisiert. Der letzte obere Molar (M3) verlängert bei *T. cuvieri* F. die Zahnreihe in die distale Richtung und hat fast triangulare Kaufläche. Die Backenzähne bilden kurze Wurzel. Der Schmelzschlingenmuster von *T. cuvieri* F. ist typisch lamellenartig. Der Zahnschmelz ist relativ dick. Die inneren Lamellen sind immer ohne den Zement. Aus den Strien und Striiden sind oft nur die Hypostria und der Hypostriid ausgebildet. In einigen Fällen sind sie mit dem Zement gefüllt.

Die Gattung *Castor* hat den Querschnitt den Schneidenzähne typisch dreieckig; ihre Labialfläche ist fast flach und glatt. Die bewurzelten Backenzähne sind pentalofodont mit offnen Synklinalen (Para-, Meso-, Meta-, Hypostrien und den Hypostriiden). Alle sind mit dem Zahnzement gefüllt. Bei älteren Individuen ist die Basis der Backenzähne mit Wurzelzement bedeckt.

Die Maße (in mm): An den Schneidenzähnen wurde die Höhe (sagittal) und Breite (transversal) des Schneidenzahn gemessen. Backenzähne: die grösste Länge (proximal–distal) und die grösste Breite (palatinal–buccal) der Kaufläche und der Zähnsäule gemessen. Die gemessenen Werte werden mit den Funden aus den verschiedenen europäischen

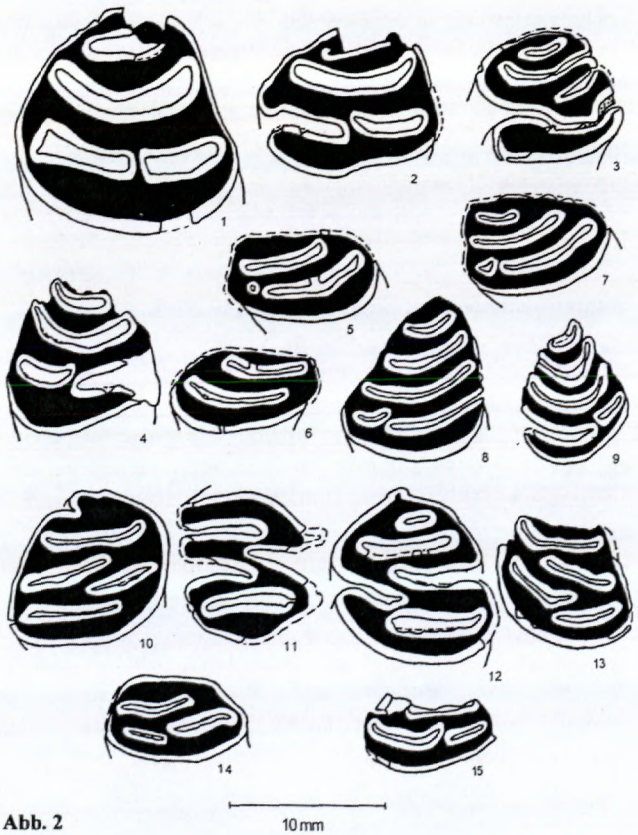


Abb. 2

Fundorte (Günther 1965) verglichen (Tab. 2 a–d). An den vollständigeren Backenzähnen wurde die Länge der Schmelzschlingen und die Länge der Zahnsäule nach W. D. Heinrich (1991) gemessen. Die Kauflächen sind in Abb. 2 abgebildet.

Der Längen/Breiten-Index der Kaufläche aller Zähne schwankt im Interval 0,7–1,2 mm. In Přezletice und Chlum I. haben die Zähne den typische Bau – die lamellare Struktur der Kaufläche (Schreuder 1929). In Chlum IV. haben die Zähne sehr große Variabilität in der Morphologie, vor allem an den Prämolaren. Der dritte obere Molar (M3) aus Chlum IV. Höhle ist molariform und hat demnach nicht die typisch verlängerte Form der Occlusalfläche.

ZUSAMMENFASSUNG

Aus den mittelböhmischen Fundstellen des älteren Pleistozäns: Höhlen/Höhlenruinen von Chlum I. und IV und Přezletice sind die Belege des Bibers *Trogontherium cuvieri* Fischer beschrieben und mit anderen ähnlichen Vorkommen Europas verglichen.

Ähnlich wie in anderen europäischen biharischen Lokalitäten (z. B. Süssenborn, Untermassfeld und Voigtstedt (BRD), Gombasek 1 (Slowakei) und Betfia 2 (Rumänien)) kommt in Chlum auch die Gattung *Castor* vor. Dagegen in der gleichaltrigen Fauna der benachbarten Höhle C 718 bei Koněprusy mit reichlichen Funden von *Castor fiber* fehlt *Trogontherium* vollständig. Im Gegensatz zu *Castor* ist das Vorkommen von *Trogontherium* wahrscheinlich auf größere Flüsse gebunden.

Tab. 1

Die Fundstäten	I	i	P	p	M	m	Oberkiefer	Unterkiefer
Chlum I.	2	1	3	–	1	–	–	–
Chlum IV.	–	2	1	4	–	2	–	2
Přezletice	–	–	–	–	4	–	1	–

Tab. 2a

	P^4	M^1	M^2	M^3
Tegelen	10,5–12,5	7–8	7–8	10,2–12,0
Mosbach	12,8	8,8	9,3	11,7–12,4
Jockrim/Mauer	–	8,1–9,2	–	10,0
Voigtstedt	10,1	8,3	8,8	12,5
Chlum I.	10,55–11,85	–	–	9,4
Chlum IV.	10,15	7,55	–	–
Přezletice	–	6,65–7,45	7,9	12,65

Tab. 2b

	P^4	M^1	M^2	M^3
Tegelen	11,5–13,6	8,6–9,9	8,4–9,7	8,5–10,0
Mosbach	13,5–14,5	10,3	10,0	9,3–10,0
Jockrim/Mauer	–	–	–	–
Voigtstedt	13,3	9,5	9,9	8,7
Chlum I.	13,35–14,45	–	–	9,2
Chlum IV.	8,9	10,6	–	–
Přezletice	–	10,05–10,3	9,95	9,6

Tab. 2c

	P^4	M^1	M^2	M^3
Tegelen	13,7–14,5	8,1–9,4	7,9	8,6–9,7
Mosbach	17,5	9,0–9,5	9,0	10,5
Jockrim/Mauer	–	–	–	–
Voigtstedt	15,5	8,0	7,2	8,5
Chlum I.	–	–	–	–
Chlum IV.	10,75–14,15	9,15	–	–
Přezletice	–	–	–	–

Tab. 2d

	P^4	M^1	M^2	M^3
Tegelen	8,5–10,4	9,3–10,4	9,0–10,8	7,8–9,7
Mosbach	8,5–10,4	9,6–11,5	9,0–11,3	–
Jockrim/Mauer	–	10,2–10,4	10,6–10,9	–
Voigtstedt	11,1	9,5	9,9	9,2
Chlum I.	–	–	–	–
Chlum IV.	9,75–11,45	11,2	–	–
Přezletice	–	–	–	–

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REPORT ON FERNS OF THE BOHEMIAN CENOMANIAN AND THEIR SPORES IN SITU

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Abstract: Two ferns of the Bohemian Cenomanian flora, *Anemia* cf. *fremontii* Knowlton (Schizaeaceae) and *Nathorstia* cf. *fascia* (Bayer) Nathorst (Matoniaceae) are characterized on the basis of fertile material in respect of gross morphology and spores *in situ*. The affinties and relatioship to modern and fossil representatives of these groups are discussed.

INTRODUCTION

Ferns represent an important component of the Bohemian Cenomanian flora, which is well-known for its high diversification of angiosperms, and frequent occurrence of gymnosperms. Although frequently recorded, the ferns have not been studied in detail through the last several decades.

First comprehensive study on Cretaceous ferns of the Bohemian Cenomanian was published by Velenovský (1888). Further taxa were described later by Mařík (1901), Bayer (1914), Velenovský and Viniklář (1926, 1927, 1929, 1931), Knobloch (1984a, 1984b, 1987, 1999, 2001). Most genera described were considered as members of the families Marattiaceae (*Marattia*), Dicksoniaceae (*Thyrsopteris*) or Polypodiaceae (*Polypodium* subg. *Drynaria*, *Asplenium*) and Gleicheniaceae (*Gleichenia*). The present study shows that beside Gleicheniaceae the other described ferns belong to presently relictual families Matoniaceae and Schizaeaceae.

New material collected within the last decade is described here in and compared to the old collections of Velenovský, Viniklář and Bayer. In several occasions, spores *in situ* were recorded, studied and used for systematic classifications.

MATERIAL AND METHODS

Studied fossil ferns which come from claystones of the Peruc-Korycany Formation of the Czech Cretaceous Basin are housed in the collection of the National Museum. Age of the Peruc-Korycany Formation is suggested as an upper part of the Middle Cenomanian (Pacltová 1977, 1978).

Standard methodology was employed for maceration and preparation of spores (Bek 1998, Collinson 1999). Palynological maceration technique of extraction included preparation by needle or previous bulk maceration Material was treated in diluted hydroflurid acid (HF, 4 %) to dissolve remaining silica and silicates. Then Schulze's solution ($KClO_3$ and HNO_3) was applied in case of compressed material (Wellman, Axe 1999, Batten 1999).

Part of extracted macerates was mounted in glycerine jelly (2 or 3 preparations from one taking) for light microscopy (Olympus BX 40). In case of very well-preserved material part of macerates was fixed on metal pins or cylindres (stubs) and was observed in scanning electronic microscope (SEM). Detailed morphology of fertile fern fronds has been also studied in SEM (Collinson 1999).

SYSTEMATICS

Schizaeaceae

Anemia cf. *fremontii* Knowlton
Pl. 1, figs. 1–11
Locality: Horoušany, Kamenná Panna

Tripinnatifid triangular frond with lanceolate pinnae shows ovate pinnules attached to axes by broad bases. Each pinnule is nearly oval in appearance bearing sporangia of unknown arrangement (pl. 1, figs. 1–3). Sporangia contain cicatricose spores (pl. 1, figs. 4–9). They are tetrahedral, trilete with leasurae (pl. 1, figs. 8, 9) indistinctly extending at least 75% spore radius. Muri are narrow (2–3 μm), separated by narrow (1 μm) lumina (pl. 1, fig. 5), and anastomosing mutually in equatorial region. Spore diameter in equatorial view ranges from 38 μm to 50 μm.

The spores of the studied material have characteristic arrangement of muri, known *in situ* only from the species *Anemia fremontii* Knowlton forma *fertilis* Andrews (Dettmann and Clifford 1992). Comparison with the type material of *A. fremontii* is necessary for definite conclusions. Spores of *Anemia* cf. *fremontii* studied here are similar to spores of the recent *Anemia mexicana* subgenus *Anemiorhiza* in having canaliculate exine with 3 sets of muri.

The associated sterile fronds of *Anemia* cf. *fremontii* are closely similar to *Onychiopsis capsulifera* Velenovský. Identity of these two species remains as a task for our future studies.

Matoniaceae

Nathorstia cf. *fascia* (Bayer) Nathorst
Pl. 2, figs. 1–9
Syn:

Drynaria fascia Bayer 1899, p. 10, figs. 5, 5a
Locality: Hloubětín-Hutě, Praha

Fragments of isolated lanceolate pinnules (10–25 mm long and 3–6 mm wide) show two rows of sori on abaxial surface running parallel to the pinnula midvein (pl. 2, fig. 1). Each sorus (pl. 2, fig. 2) is tightly covered by circular, probably persistent indusium, 1.5–2 mm in diameter. Indusium is flat and relatively smooth, showing delicate radial striation. Distance between two sori is 2.5 mm. Sorus consists of 12–14 radially arranged wedge-shaped sporangia 500 μm long (pl. 2, figs. 3, 4). Spores are trilete (pl. 2, figs. 5, 6), triangular in equatorial outline, leasurae distinct, slightly raised extending 70–75 % of spore radius (pl. 2, figs. 7); tori-interradial thickenings frequent (pl. 2, fig. 6), exine psilate. Spore diameter in equatortial view ranges from 35 μm to 50 μm.

Nathorstia fascia was described by Bayer (1899) from Vyšehořovice under a generic name *Drynaria* (Bory) J. Smith as a member of the family Polypodiaceae. Type of the sporangia and spores does not confirm previously suggested affinity and clearly argues for Matoniaceae (see van Konijnenburg – van Cittert 1993). The genus *Drynaria* has long-stalked sporangia and verrucate and echinate spores. The genus *Nathorstia* Heer emended by Krassilov (1964) is characterized by 8–24 separate wedge-shaped sporangia arranged in large sori covered by circular indusium.

Nathorstia cf. *fascia* differs from *Matonidium* Schenk (sensu Hirmer and Hörhammer 1936) in larger indusium and wedge-shape sporangia, from *Phlebopteris* it differs in absence of indusium, lower number of sporangia in sorus and smaller sorus diameter (van Konijnenburg – van Cittert 1994, tab. II). Material studied differs from recent *Matonia* R. Br. and *Delesorus* Skog in wedge-shaped sporangia (van Konijnenburg – van Cittert 1994, tab. I).

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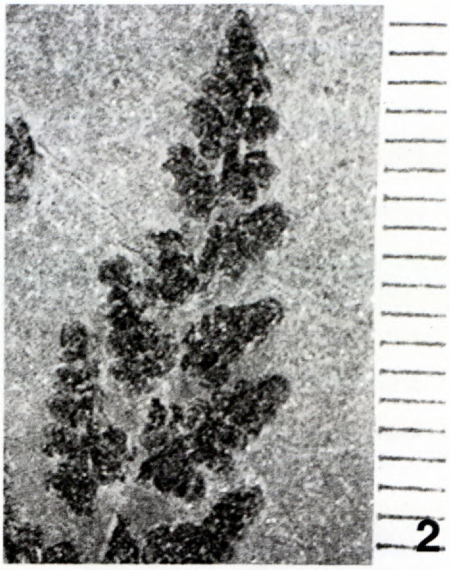
















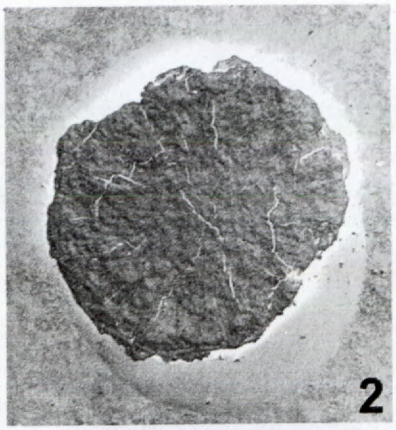
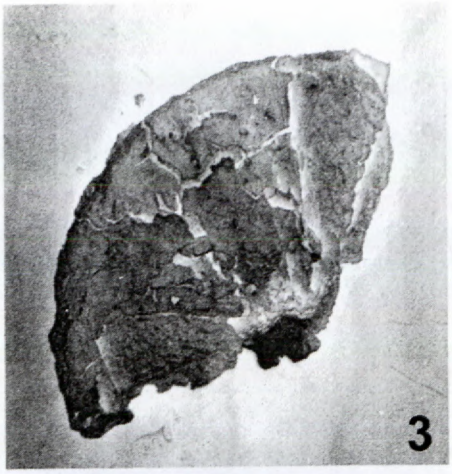
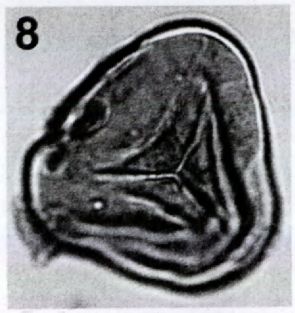


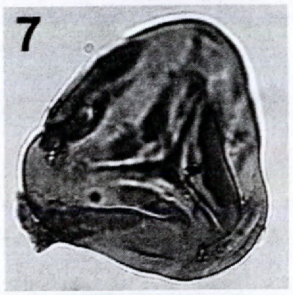


Plate 1

***Anemia* cf. *fremontii* Knowlton, Horoušany, Kamenná Panna**

1 – Large fragment of compound fertile leaf, F 2930, x 1,
2 – Leaf pinna bearing sporangia; detail of fig. 1, F 2930, x 3.8,
3 – Leaf pinna bearing sporangia, F 2929, x 3,
4 – Fragment of sorus showing spores, F 2929, SEM, x 220,
5 – Spores with interradial thickenings, F 2929, SEM, x 880,
6 – Part of sporangium, F 2929, x 90,
7 – Tetrade, F 2929, x 400,
8, 9 – Spore in two different focusing levels, F 2929, LM, x 440,
10, 11 – Spore in two different focusing levels, F 2929, x 440.



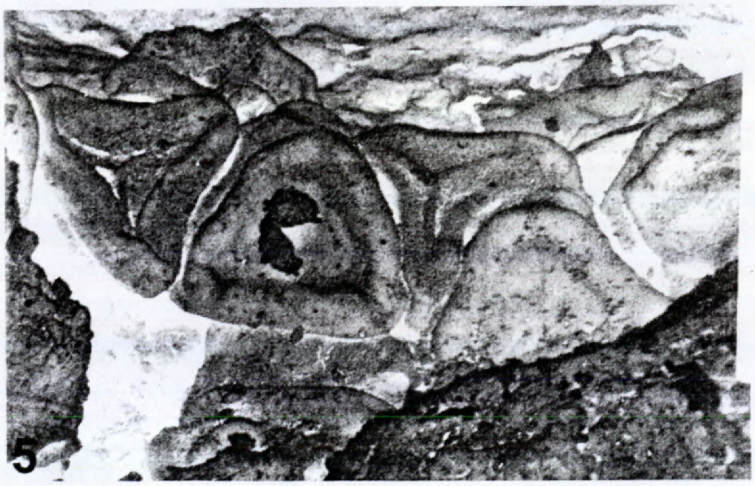



Plate 2

Nathorstia cf. *fascia* (Bayer) Nathorst, Hloubětín-Hutě, Praha

1 – Leaf fragment, showing arrangement of sori, F 2927b, x 4,

2 – Sorus showing large indusium, F 2928, SEM, x 27 ,

3 – Fragment of sorus with four wedge-shaped sporangia, F 2928, SEM, x 53,

4 – Detail of fig. 3 showing sporangium, sporangium wall and spores, F 2928, SEM, x 107,

5 – Spores with interradial thickenings, F 2928, SEM, x 600,

6 – Spores showing trilete mark, F 2928, SEM, x 460,

7, 8 – Spore in two different focusing levels, F 2927b, LM, x 700,

9 – Tetrade, F 2927b, LM, x 680.

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OLIGOCENE PLANT MEGAFOSSILS AND ENVIRONMENT FROM THE NEWLY RECOVERED LOCALITY OF THE HOLÝ KLUK HILL NEAR PROBOŠTOV (ČESKÉ STŘEDOHOŘÍ MOUNTAINS, CZECH REPUBLIC)

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Abstract: The site of Oligocene plants, the Holý Kluk hill near Proboštov, which has been lately recovered for new collecting after more than 100 years, is characterised in terms of the flora, vegetation and environment. The flora includes 2 ferns, 3 conifers and more than 60 angiosperms. The reconstructed vegetation corresponds to the Mixed Mesophytic Forest with a considerable representation of thermophilic elements surviving from the latest Eocene. The site arose in a lake filled with volcanogenic deposits during a calm period of the volcanic activity about 29–30 MA according to the radiometric data. The composition of the flora and the aspect of the vegetation corroborate the subtropical climate of this time interval with frostless winters and a high amount of the annual precipitation.

INTRODUCTION

The volcanic complex of the České Středohoří Mountains has been recently in focus of new attempts to re-evaluate this geological unit of the Bohemian Massif from various aspects. Besides petrological research concentrated on the origin, succession and extent of magmatism in this area (Bellon *et al.* 1998; Ulrych *et al.* 1999, 2001; Cajz 2000), also palaeontological "Lagerstätte" connected mostly with volcanogenic sediments and well known in many cases since the 19th century have attracted attention of several specialists in ichthyology (e.g., Gaudan 1996, 1997; Micklich, Böhme 1997), entomology (Prokop 2001, in prep.), palynology (Konzalová 1981, 1996) and palaeobotany (e.g., Kvaček, Walther 1995, 1998). The first author of the present paper (M. R.) submitted in 1997 a wider project, sponsored by the Ministry of Culture CR aiming at a revision of all so far known sites in the field and a review of available palaeontological data in a form of the data-base (Radoň 2001). His field work efforts have resulted in discoveries of several new plant localities that yielded noteworthy new taxa (e.g., Malá Veleň with palm foliage – Radoň 2002), and also in finding outcrops not accessible to date. The latter case applies to the diatomite/tuffite/lignite strata known in the older palaeobotanical literature as Holaikluk (Engelhardt 1876) – at present the Holý Kluk hill at Proboštov. The site has been temporally exposed after more than 100 years again in the years 1995 to 2000 and several hundreds of plant fossils have been recovered since. Unfortunately, the outcrop was again much devastated by flooding and landslide in autumn 2000. The original collection made by Castelli in the 19th century, and studied by Engelhardt (1876), is missing, having been probably destroyed after the death of its owner. And so the recent collections offer an opportunity to re-evaluate this important flora within the Oligocene succession in Central Europe. The first plant element studied in detail from there was *Calocedrus suleticensis* (Brabenec) Z. Kvaček (1999). Another fossil plant, which required a special study, was *Polypodium radonii* Kvaček (2001). The present paper summarises information on geology, dating and previous research related to the Holý Kluk hill (by M. R. – see also Radoň 2001, in Czech), and evaluates its flora, vegetation and palaeoenvironment (by Z. K., maples by H. W.) in the context of other volcanic floras of N. Bohemia and adjacent Saxony. All the fossil material described below as well the database are housed in the Regional Museum, Teplice, a small additional collection from Holý Kluk (Jókely 1858) was recovered in the Geological Survey in Vienna.

MATERIAL AND METHODS

The Holý Kluk hill (former names – Hollaygluck, Holai--Kluk, Holaikluk, Holaykluk) attaining 375 m alt. is situated about 0.5 km north-east of the village of Proboštov, 3.5 km south-east of Velké Březno and about 7 km east-south-east of the town Ústí nad Labem – coordinates: 50° 37' 54" N lat. and 14° 09' 21" E long. (Fig. 1). Its volcanic body is well seen in the landscape and represents a shallow intrusion of the sodalite trachyte wedged into pyroclastics and tuffitic (volcanogenic) sediments accompanied by coal seamlets. The existence of volcanogenic sediments on the top of the

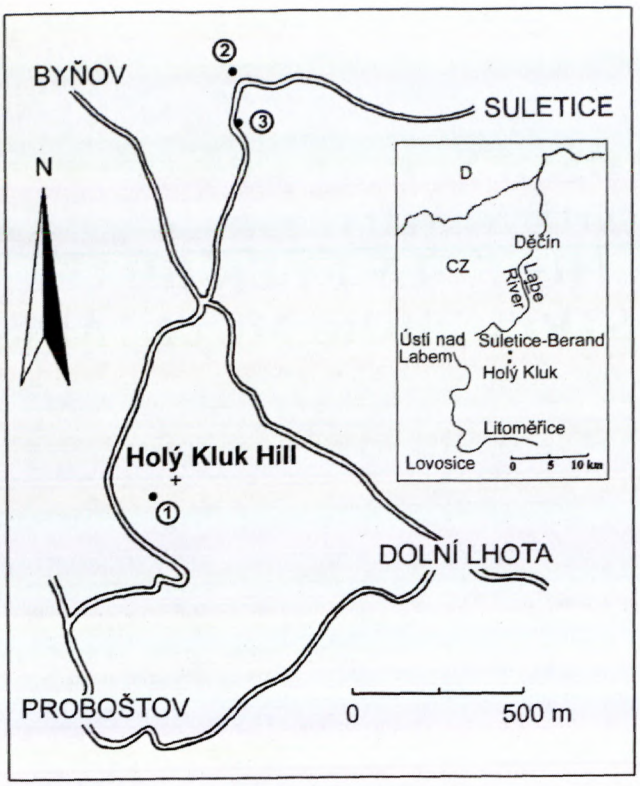


Fig. 1 Geographical situation of the localities at the Holý Kluk hill and Suletice in northern Bohemia: 1 – Holý Kluk outcrop, 2 – Suletice-Berand, 3 – Suletice outcrop (drawn by M. Radoň).

hill corroborates an intrusive character, i.e. the lacolite type, of this body (Shrbený 1967). The hill is demarcated by deeply cut valleys of the Homole and Proboštov creeks, which merge on the northern foot and descend into the Labe (Elbe) valley in the environs of Velké Březno. Fossiliferous layers are bound to tuffitic/coal sedimentation underlying the volcanic body and occasionally outcropping on the southeastern side of the hill on the bank of the Proboštov Creek.

F. A. Reuss (1793) gave the first geological and petrological data about the section of the Holý Kluk hill. A. E. Reuss (1840) published a detailed description of the locality. He described two sections. One section was situated on the southern slope beneath the trachyte body showing columnar jointing. This outcrop exposed a lignite seamlet partly metamorphosed, inclined at 18 grade north-north-east (hora 4) parallel with the bottom of the trachyte (not metamorphosed itself), underlain by the shale claystone with leaf impressions. In another section of an old working attempt (not visible on the surface to date) Reuss (1840) described two lignite seamlets under the trachyte, which were separated by pyroclastic layers of tuffites and conglomerates (see Reuss 1840, fig. 1/5). Jokély (1858) described at Holý Kluk also two lignite seamlets separated by basaltic psammitic tuff. He noted in addition a brown to light yellow claystone containing plant impressions in the underlying basalt tuff (see Jokély 1858, fig. 8). Krejčí (1869) mentioned this locality only briefly. Engelhardt (1876) described the section roughly in the same way as Jokély, after a visit to the site together with one of the best students of this region, Albin Castelli (see below). Hibsch (1903) situated the outcrop of the fossiliferous bituminous shale on the western slope of the hill, opposite to the gallery Františka (Franzisken-Stollen) at 280 m alt. This place does not correspond to the outcrop recovered by the present research. According to Purgold (1883), fossil leaf impressions occurred in the shale claystone in the steep rock wall on the right bank of the creek near the gallery Vavřinec. In our opinion, this is roughly the place of our collections. Shrbený (1967), who carried out geological mapping there, gave recent data on the geology and petrology of the Holý Kluk hill. He describes petrology of the trachyte, together with a chemical analysis (No. 19 in Shrbený 1967) and reports on three occurrences of tuffite rocks on the southeastern and southern sides of the hill. Two of them are described in detail in Shrbený and Macák (1967 – documentation points No. 86: lapilli-bearing tuff, pellitic tuff and coal clay at a path 350 m south-east of the hill top, and No. 708: about 11 m long and 1.5 m high outcrop in pyroclastics on the creek bank on the south-west hill side).

The section recovered by the first author (M. R. together with Jindřich Babák) in 1995 is situated in a narrow meander of the creek at 310 m alt. on the SW foot of the Holý Kluk hill. The outcrop is about 10 m long and 5 m high. On the right side, a contact between the trachyte and the sediments

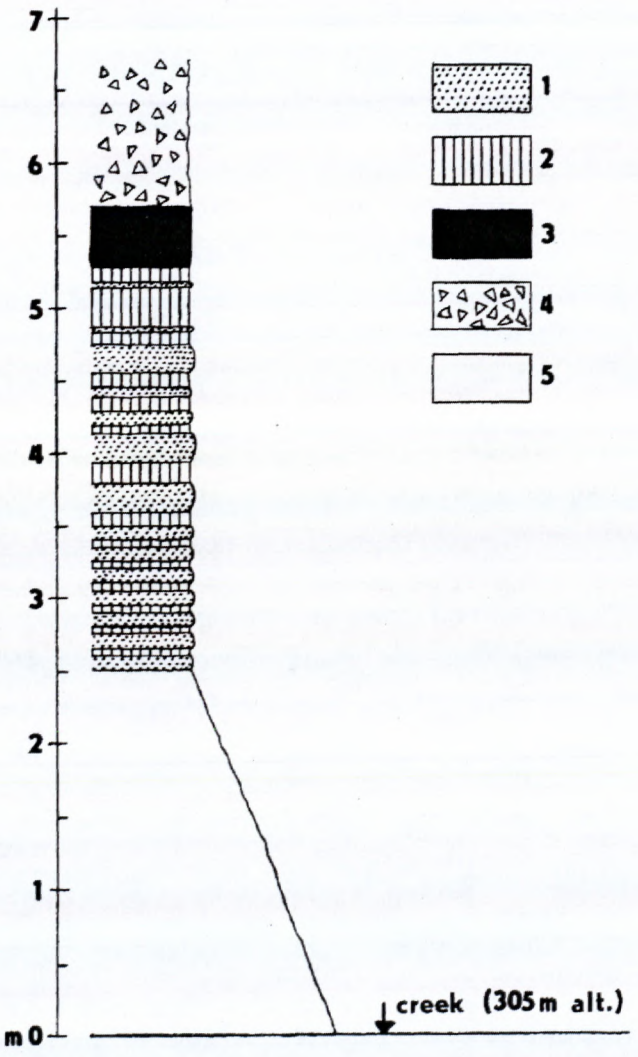


Fig. 2 Geological section of the outcrop on the SW slope of the Holý Kluk hill: 1 – psammitic tuffite, 2 – claystone, 3 – fragmented coal, 4 – talus of trachyte blocks, 5 – deluvial talus (drawn by M. Radoň in 1995).

is visible. As recorded by the first author and Zdeněk Dvořák in 1995, the succession of layers immediately underlying the trachyte approximately in the middle of the outcrop (Fig. 2) includes (from above):

40 cm lignite to lignite clay, partly re-deposited,

190 cm volcanogenic, slightly bituminous yellow-brown shale claystone (layers 5–15 cm thick) with interbeds (10–20 cm thick) of grey-greenish to yellow-brown psammitic-psefitic tuffite (both rock types fossiliferous, the former with some bedding planes overfilled by leaf impressions, the latter also with rare fruit fossils),

320 cm tuffite with rare thin interbeds of claystone, exceptionally yielding fossils, partly covered by talus,

water table of the creek.

The equivalent layers, this time without any fossils, crop out about 60 m downstream (documentation point No. 708 of Shrbený and Macák 1967).

The first information on plant impressions occurring at Holý Kluk is available in A.E. Reuss (1840). Jokély (1858) published a list of dominating plant species (identified by F. Unger), stressing that Holý Kluk was one of the richest sites visited by him. He lists the following species (our revisions of the material housed in the Geological Survey, Vienna in brackets): *Glyptostrobus europaeus* (*Calocedrus suleticensis*), *Podocarpus eocenica* (lacking), *Carpinus grandis* (confirmed), *Populus mutabilis* (cf. *Carya serrifolia*), *Celastrus andromedae* (*Engelhardia orsbergensis*) and *Juglans elaenoides* (*Sloanea artocarpites*). This list was reproduced later by Zincken (1867). Engelhardt (1876) was the first (and the last) who described in detail all higher plants, basing on the extensive collection made by himself and the well known amateur collector, mine manager in Proboštov, Albin Castelli (Engelhardt 1876: 345). Engelhardt and Castelli visited the fossiliferous outcrop for several days and collected a large amount of fossil plants, described and illustrated in Engelhardt (1876). Castelli was very happy to collect there and visited this site several times with friends and specialists (Held 1893). Unfortunately, his collections disappeared after his death. Hence the revision of Engelhardt's identifications can be based at the moment on mere illustrations (see table 1). The floral lists were later reproduced in Krejčí (1877), Engelhardt (1878), Katzer (1902), and Hibsch (1903). Engelhardt (1891) mentioned some additional taxa without any reference to the collector. Wentzel (1881) and Menzel (1897) published comparisons between the flora of Holý Kluk and the others from wider surroundings of Proboštov and Suletice (in the form of tables).

Kafka (1911) in his highly idealised (and misleading) section of the volcano-sedimentary strata of the České Středohoří Mts. assigned his level No. 14 near Suletice to the top of his stage II. This level contained coal clay 3.8 m thick with clay lignite, bituminous claystone, fine-grained black tuffite, coalified wood, plant compressions and was correlated to the middle (i.e. main) lignite seam of the Proboštov coal field and the Holý Kluk site. A partial revision of the flora of Holý Kluk illustrated by Engelhardt (1876, 1891) was attempted by Bůžek (1967). Further data on selected elements have been published by Kvaček (1999 – *Calocedrus*, 2001 – *Polypodium*) and Kvaček *et al.* (2001 – *Sloanea*).

Besides land plants, also remains of diatoms were reported from the tuff of Holý Kluk (Grunow 1882, Řeháková 1967). Unfortunately, an attempt to get a new spectrum of diatoms from the newly recovered fossiliferous layers of Holý Kluk failed (Získalová 1999: 50). Besides plant remains, new collections include fragmentary skeletons of frogs (not identified) and fossil insects. The latter were preliminarily identified as representatives of the family Curculionidae (Coleoptera) besides numerous not identifiable, poorly preserved remains (Prokop 2001).

All specimens studied have been collected by the first author (M. R.), his father and friends. During 5 years of collecting activities more than 1500 specimens have been gathered. Most of the fossil remains have been found embedded in the yellow-brown bituminous claystone, which brakes into pieces during desiccation. The preservation of larger blocks becomes a problem after the material dried up. Sometime slabs have been saved from decomposition by saturation in artificial resins. Plant remains and other megafossils are preserved as mere impressions, with vaguely expressed venation, or molds in cases of fruits, seeds and animal remains. No cuticle or testa fragments have been observed on the surface of the rock. Hence routine gross morphological comparisons have been employed for determinations. All newly collected specimens are housed in the Regional Museum, Teplice and curated by the first author. The second and third author made the photography by the cameras Practica BX 20 and Nicon F 601 with macro-lenses.

SYSTEMATIC DESCRIPTIONS

The following review that is based on the new collections (coll. *M. Radoň 1995–2000*) includes 2 ferns, 3 conifers and more than 60 angiosperms (see table 2). Only a limited number and fragmentary nature of the specimens prevented us to bring ranges of size variation and more precise morphological data. Most taxa have been identified with the aid of comparisons with the previously studied sites at Suletice-Berand (Kvaček, Walther 1995), Kundratice (Kvaček, Walther 1998) and according to special systematic studies (e.g., Bůžek, Holý, Kvaček 1967; Bůžek, Kvaček, Walther 1981; Walther 1972; Kvaček 1984; Kvaček, Konzalová 1996; Kvaček 1999, 2001; Kvaček *et al.* 2001). Our tentative revisions of identifications by Engelhardt (1876) are included in table 1, but a study of the actual specimens is required for definite judgement. The floral list given by Jokély (1858) is commented above.

Polypodiophyta

Dryopteridaceae

cf. *Rumohra recentior* (Unger) Barthel

Pl. 1, figs. 1–2

Material: 2 leaf frond fragments.

The fragmentary sterile fronds with finely dissected margins of leaf segments and anadromous architecture represent so called *Rumohra recentior*, a rare fern, revised by Barthel (1976), and known also from the Doupov Mountains volcanic complex at Valeč (Bůžek *et al.* 1990). Its stratigraphic range is from the Eocene to Miocene

(Barthel 1976). The generic delimitation of *Rumohra* Raddi is at present taken much narrower and most of its species have been re-assigned to *Arachnoides* Bl., another dryopterid fern with anadromous fronds (see Kramer in Kramer, Green 1990).

Polypodiaceae
Polypodiums radonii Z. Kvaček
Pl. 1, figs. 3, 7–8
Material: 4 leaf frond fragments.

The recovered fragmentary sterile simple pinnatifid fronds recall some representatives of the *Polypodium vulgare* L. complex (e.g., *P. interjectum* Shivas, *P. macaronesicum* Bobrov) by the nearly perpendicular attachment of long falcate entire-margined pinnae. Like in some species of *Polypodium* L. sensu Ching (Lu 1999), the secondary veins are free, three times anadromously branched, and veinlets terminate by a rounded enlargement (i.e. the hydathode on the leaf upper surface). The venation of the pinnae is vaguely seen but does recall in the degree of forking the above listed species of *Polypodium* from Europe and Macaronesia. A fertile fragment of this fern was recovered also at Bechlejovice (Knobloch 1994, as cf. *Woodwardites muensterianus* (C. Presl in Sternb.) F. Braun), which yielded spores of the *Verrucisporites*-type. A more detailed study of foliage and spore morphology in the family Polypodiaceae (including extant representatives) was undertaken to evaluate this new fern more precisely (Kvaček 2001).

Pinophyta

Cupressaceae
Tetraclinis salicornioides (Unger) Z. Kvaček
Pl. 1, fig. 9
Material: 72 twig fragments or isolated twig segments, one seed.

Twigs with opposite branching pattern bear flattened cladode-like segments, which are formed by fully fused leaf whorls. Also a single seed at hand perfectly corresponds with those of this common Tertiary European conifer, newly recovered also in the Oligocene and Miocene of North America (Kvaček *et al.* 2000).

Calocedrus suleticensis (Brabenec) Z. Kvaček
Pl.1, figs. 4–5, 11
Material: 47 specimens, mostly twig fragments, also one seed cone and one seed (partly orig. Kvaček 1999).

New collections from the Holý Kluk hill afforded evidence that such mostly oppositely branched foliage shoots first recovered at Suletice and ascribed to *Libocedrus* (*L. suleticensis* Brabenec) belong in fact to the genus *Calocedrus* Florin. A seed cone (with its counter-impression) and a seed showing very typical characters of this genus were found in close association at Holý Kluk (Kvaček 1999). Engelhardt (1876, pl. 6, fig. 12) illustrated a similar seed and designated it as *Embothrium salicinum* Heer, but we are not sure without a study of the specimen, if it truly belongs to *Calocedrus*. Similar dicot seeds of *Saportaspermum* occur in many European floras, and also at Holý Kluk (see below). The twigs are oppositely or rarely alternately branched. The former are clearly distinguishable from *T. salicornioides* by distinct demarcated lines between lateral and facial scale leaves. Besides Suletice and Holý Kluk, the twigs of *C. suleticensis* have been recovered in a few sites in Europe (Lower Oligocene of Budapest by Kvaček, Hably 1998 – the earliest publication of the recombination of *Calocedrus suleticensis* (Brabenec) Z. Kvaček, Upper Oligocene of Krumvíř in Moravia and Evros in Macedonia, as well as Lower Miocene of Kimi, Greece, own observations).

Cephalotaxaceae
cf. *Cephalotaxus parvifolia* (Walther) Z. Kvaček et Walther
Pl. 1, fig. 6
Material: 6 needle impressions.

The recovered narrow and medium long needles with a short petiole match those known from Kundratice and Seifhennersdorf, which were re-interpreted as *Cephalotaxus parvifolia* basing on epidermal evidence (Kvaček, Walther 1998). Similar remains were identified as cf. *Cephalotaxus* sp. from the sites at Suletice (Kvaček, Walther 1995).

Taxaceae
cf. *Torreya bilinica* Saporta et Marion
Pl. 1, fig. 10
Material: 1 needle impression.

These up to 3 mm wide needles, which have often been identified as *Podocarpus* (e.g., Engelhardt 1885), occur rarely at Holý Kluk. Because of the lack of leaf epidermal evidence, the identification must remain tentative. *Torreya bilinica* is an accessory conifer in Oligocene volcanic floras of the České Středohoří Mts. (Žichov, Kundratice, Markvartice) and adjacent sites (Seifhennersdorf, Kleinsaubernitz – Walther 1996, 1999).

Magnoliophyta

Magnoliaceae
cf. *Magnolia* sp.
Pl. 2, fig. 1
Material: 24 leaf impressions.

The lauroid venation of these entire-margined leaves suggests an affinity to Magnoliidae. Similar large elliptic leaves have been mostly assigned to the genus *Magnolia* L. (e.g., Mai 1963; Kvaček, Walther 1995, Walther 2003). The specimens at hand are not characteristic enough to be identifiable to the species level.

Lauraceae
Laurophyllum cf. *acutimontanum* Mai
Pl. 2, figs. 2, 3 left
Material: 5 leaf impressions.

Several lanceolate lauroid leaves with entire margin and pinnate venation match in morphology *L. acutimontanum*, a common member of Late Eocene and Oligocene floras in Central Europe. Its affinities remain obscure.

Laurophyllum sp.
Pl. 2, fig. 6
Material: 135 leaf impressions.

Because of the lack of leaf anatomy, identification of

most leaf impressions suggesting lauroid affinities must remain open.

Daphnogene cinnamomifolia (Brongniart) Unger
Pl. 2, fig. 7

Material: 48 leaf impressions and 2 fruits.

Triveined leaves of this sort are very common in the Oligocene of Europe. According to correlation/co-occurrence of fruits (*Cinnamomum costatum* (Mai) Pingen, Ferguson et Collinson) and leaves (*Daphnogene polymorpha* (A. Br.) Ett.) in the Miocene of Kreuzau, it seems likely that at least some of such triveined leaves must belong to the genus *Camphora* Fabr. (i.e. *Cinnamomum* Schaeffer sect. *Camphora*) (see Pingen *et al.* 1994). Although impressions of non-cupulate fruits similar to *Cinnamomum* do occur at Holý Kluk in association of these leaves, the lack of precise information on their structure prevents us to be sure about generic affinities of the above extremely variable morpho-species.

Nymphaeaceae
cf. *Dusembaya* sp.
Pl. 2, fig. 4

Material: 15 seeds.

Similar small, strongly compressed *Brasenia*-like seeds occur often in the late Palaeogene of the České Středohoří Mountains and adjacent sites (e.g., Mai 1963; Kvaček, Walther 1998). Their preservation is rarely good enough to allow more precise identifications (Mai 1988).

Cercidiphyllaceae
Cercidiphyllum crenatum (Unger) R. Brown
Pl. 2, figs. 5, 8

Material: 23 leaves and 2 infructescences.

The leaves of this plant are well recognisable even in fragmentary specimens. Clusters of follicles occurring often in the association also at Holý Kluk, and even fruiting twigs (Kvaček, Konzalová 1996) bearing both foliage and fruits (Bechlejovice) afford evidence that only true *Cercidiphyllum*, and not extinct *Joffrea (Nyssidium)*-like taxa occur in the middle Tertiary of Central Europe. This tree is common in most Oligocene sites of the České Středohoří Mts. and represents a deciduous (modern Arcto-Tertiary) element. It is also known in many localities from Oligocene to Pliocene in Europe (Jähnichen *et al.* 1979; Mai, Walther 1988).

Platanaceae
Platanus neptuni (Ettingshausen) Bůžek, Holý et Z. Kvaček
Pl. 3, fig. 1

Material: 30 specimens including leaves, stipules, 1 stalked pistillate inflorescence and 1 infructescence.

Leaves, stipules and infructescenses of this peculiar plane tree, which was well spread in the European middle Tertiary, are well represented in the Holý Kluk collection. They match perfectly the other occurrences. A recent study on its relatives, *P. bella* (Heer) Z. Kvaček, Manchester et Guo, and *P. fraxinifolia* (Johnson) Walther, has shown that the whole group must be separated from other representatives of *Platanus* L. in a new subgenus *Glandulosa* Z. Kvaček, Manchester et Guo. This subgenus differs from the rest of the genus in characteristic large peltate glands occurring on all organs, in morphology of inflorescences and other traits (Kvaček, Manchester, Guo 2001). Despite its Arcto-Tertiary origin (an ancient Arcto-Tertiary element *sensu* Kvaček 1994), this tree was certainly thermophilic, connected with the warm humid climate. It is represented in other sites of the České Středohoří Mts. beginning with the Late Eocene locality of Kučlín, and most abundantly at Markvartice (Bůžek, Holý, Kvaček 1967, 1976).

Hamamelidaceae
cf. *Matudaea menzelii* Walther
Pl. 3, fig. 7

Material: 1 leaf fragment.

One fragmentary leaf base, otherwise similar to a larger form of *Daphnogene,* shows two basal veins starting from the very base of the leaf. Tertiary veins are extremely thin. This fragment matches perfectly the type material of *Matudaea menzelii* Walther described from the Lower Oligocene of Haselbach (Mai, Walther 1978; Walther 1980). Similar fragments, also without cuticle structure, were described from Suletice-Berand (Kvaček, Walther 1995) and Kundratice (Kvaček, Walther 1998) and with cuticles remains from Kleinsaubernitz, Saxony (Walther 1999).

Betulaceae
Betula cf. *buzekii* Z. Kvaček et Walther
Pl. 3, fig. 8

Material: 9 leaf impressions.

This type of betulaceous foliage differs from other Betulaceae occurring in the studied collection by coarsely double serrate margin. By the overall leaf form it matches true birches, rarely encountered in other sites of the České středohoří Mts., e.g. *Betula buzekii* Z. Kvaček et Walther at Kundratice, *B. brongniartii* sensu Ettingshausen 1866, pro parte (non Ettingshausen 1851) at Žichov, Markvartice, Matrý. In view of insufficient amount of specimens, the birch population of Holý Kluk is difficult to characterise more precisely. In any case, the leaf type is more likely to be assigned to *B. buzekii*, while that assigned usually to *B. brongniartii* differs in sharper, more dissected teeth on the leaf margin (e.g., Bůžek *et al.* 1976, pl. 6, figs. 1–3).

Alnus gaudinii (Heer) Knobloch et Z. Kvaček
Pl. 3, figs. 10–11

Material: 2 leaves.

Narrow elliptic to lanceolate leaves about 20 mm wide and 70 mm long with cuneate base and acute apex are characteristic with apically curved secondaries looping at the margin and sending side veinlets into fine teeth of the indistinctly double serrate margin. The leaves match those occurring abundantly at Kundratice (Kvaček, Walther 1998, pl. 3, fig. 3).

Carpinus grandis Unger
Pl. 3, fig. 12, pl. 8, fig. 1 left

Material: 74 leaf impressions.

Typical hornbeam foliage is common in the Oligocene and Neogene over Eurasia, but the morphology is not distinct enough to recognise various natural species, which

are based mainly on the morphology of bracts. Therefore, the above entity must be considered as a typical morpho-taxon.

Carpinus mediomontana Mai
Pl. 3, figs. 5–6

Material: 7 bracts.

Bracts matching the *C. neilreichii* complex by simple asymmetrical outline and coarsely dentate margin occur quite often at Holý Kluk, contrary to other localities, from which this species has been known (Kundratice, Bechlejovice, Suletice-Berand etc.). They vary from narrow to broader forms and in this respect they correspond best to the hornbeam population of Haselbach (Mai, Walther 1978).

Ostrya atlantidis Unger
Pl. 3, fig. 4, 13

Material: 12 leaves and 2 bracts.

Several slender leaves showing typical dense venation and long mucronate marginal teeth safely document *Ostrya.* Elliptical follicle-like bracts so typical of this genus and occurring also in other sites (Kundratice, Bechlejovice) in association corroborate this identification. At Suletice--Berand only *Ostrya*-like foliage has been encountered (Kvaček, Walther 1995).

Juglandaceae
Engelhardia orsbergensis (Wessel et Weber) Jähnichen, Mai et Walther
Pl. 4, fig. 7

Material: 152 leaflets and incomplete leaves.

Like at Suletice-Berand, complete paripinnate leaves and many isolated leaflets have been collected in association with the fruits noted below. Undoubtedly, they derived from the same plant. *Engelhardia orsbergensis* seems to be also a notable accessory element in the so-called lowland floras near Leipzig (Early Oligocene Haselbach Floral Assemblage – Mai & Walther 1978). It is noteworthy that similar fruits from the Oligocene of Oregon are not associated with this type of foliage, called also *Oreoroa* Dilcher et Manchester (1986). This means that the species of Europe and western USA are different and mainly distinguished by foliage (Hably, Kvaček, Manchester 2000).

Engelhardia macroptera (Brongniart) Unger
Pl. 4, figs. 3, 5

Material: 18 winged fruits.

The fruits of the *Engelhardia (Palaeocarya)* type with trilobate wings and triveined lobes are common. The abundant occurrence of *Engelhardia* at Holý Kluk has the only parallel in Suletice-Berand, while this element is rare in other sites of the České Středohoří Mts. This plant (in combination with the previous species based on foliage) links the extant *Alfaropsis* Iljinskaja of East Asia and *Oreomunnea* Oerst. of Central America and Mexico (Jähnichen, Mai, Walther 1977). We prefer these taxa to retain at the section rank within *Engelhardia* Lesch. *sensu lato.*

Engelhardia sp.
Pl. 4, fig. 4

Material: 1 catkin with pollen *in situ.*

Of some associated slender catkins, only one is safely assigned to *Engelhardia,* because it yielded pollen *in situ* of the *Engelhardia quietus*- type. It belongs certainly to the same plant as the other organs described above occurring in association.

Carya serrifolia (Goeppert) Kräusel
Pl. 4, figs. 1–2

Material: 63 isolated leaflets.

Juglandoid leaflets with forked craspedodromous secondaries, like those found in our collection, are safely assigned to *Carya.* Another question is, if they are characteristic enough to offer distinguishing criteria between individual species, based on fruits. In our opinion, *C. serrifolia* must be considered a morpho-taxon (like *Carpinus grandis*) and may include more species. This taxon is a common element in the volcanic floras of Central Europa. Only an imperfectly preserved fruit of *Carya* is available at the site studied (see below). Similar foliage occurs regularly in most of the leaf assemblages of the České Středohoří Mts. (Kundratice, Bechlejovice, Suletice).

Carya sp.
Pl. 3, fig. 9

Material: 1 endocarp impression and several fragments.

This mold of a nut with a short beak-like projection on the top, but showing neither the surface sculpture nor the internal disposition of the seed and septa, seems likely to belong to *Carya quadriangula* (Kirchh.) Leroy (cf. Mai 1981, pl. 27), which is known from other sites of Oligocene age in Central Europe. A similar poorly preserved fruit has been described from Suletice as *Amygdalus praecommunis* Menzel (1897).

cf. *Cyclocarya cyclocarpa* (Schlechtendal) Knobloch sensu Knobloch 1961
Pl. 4, fig. 8

Material: 19 leaflets.

Individual leaflets of this juglandoid type differ from the above-mentioned *Carya serrifolia* by sharply and regularly serrate margin, simple craspedodromous secondaries and the narrow cuneate leaflet base. Knobloch (1961) first described similar remains from the Oligocene of North Bohemia at the site of the Hrazený (Pirskenberg) hill near Šluknov. After a study of the only representative of this genus, *Cyclocarya paliurus* (Batal.) Iljinskaja, in southern China, which decidedly differs in large ovate leaflets with gently bent, not craspedodromous secondaries, we suspect a different affinity of the leaflets at hand. True *Cyclocarya* is known, e.g., from the Thierbach Floral Assemblage – in the association with typical winged fruits (Mai, Walther 1991) and exhibits semicraspedodromous venation, like its extant relative. On the contrary, our specimens and those from Hrazený and elsewhere in the České Středohoří Mts. show mostly the craspedodromous venation.

Elaeocarpaceae
Sloanea artocarpites (Ettinsghausen) Z. Kvaček et Hably
Pl. 4, fig. 9, pl. 5, fig. 5

Material: 56 leaf impressions.

Elliptical, widely serrate leaves of this new element of the European Tertiary are common both at Holý Kluk and Suletice-Berand. They were previously included as aberrant forms within *Platanus neptuni* foliage (Bůžek *et al.* 1967; Kvaček 1970) and later misinterpreted for Icacinaceae (*Icaciniphyllum* Z. Kvaček et Bůžek 1995). In the mixed craspedodromous and semicraspedodromous venation and the epidermal anatomy *S. artocarpites* matches some of extant *Sloanea* species known from southern China, Vietnam, and Laos (Kvaček, Hably, Manchester 2001) and is regularly associated with fruit remains of the *Sloanea* type (see below). Although the epidermis structure is not available in our fossils, there is hardly any doubt about the determination. More specimens of this kind were found also at Suletice-Berand (Kvaček, Walther 1995), also associated with similar fruits. Besides, *S. artocarpites* occurs sporadically also at Žichov, Kundratice and Markvartice.

Sloanea sp.
Pl. 4, fig. 6

Material: 1 fruit fragment.

Only a single finely spiny capsule valve of the *Sloanea* type has been found at Holý Kluk. It matches those associated with *S. artocarpites* elsewhere (Markvartice - Bůžek *et al.* 1976, pl. 9, figs. 9–10, as *Carpolithes* 7; Suletice-Berand – Kvaček, Walther 1995, pl. 10, fig. 3, as *Carpolithes* sp.). Both fruits and foliage differ in smaller dimensions from the record of *Sloanea* in the Tard Clay Formation in Hungary (see Rásky 1962 – as *Sloaneaecarpum*, *Sloaneaephyllum*; Kvaček *et al.* 2001 – as *Sloanea eocenica* (Rásky) Z. Kvaček, Manchester et Hably, *Sloanea elliptica* (Andreánszky) Z. Kvaček et Hably). This element, today with pantropic-subtropic distribution, is surely very thermophilic, although Manchester (1999) detected its fruits in the early Palaeogene deposits of Greenland and Rocky Mountains, partly associated with deciduous plant elements. The modern distribution of *Sloanea* (E. Australia to SW. China, tropic excl. Africa) is in favour of its tropical origin.

Malvaceae sensu lato
Tilia gigantea Ettingshausen
Pl. 5, figs. 1, 3

Material: 3 leaf fragments.

This type of tilioid foliage with the shallow cordate, strongly asymmetric base and the finely serrate margin is preserved only fragmentarily. More complete leaves of this tree from Bechlejovice are associated there with broad sub-circular to elliptic bracts without fruits and corroborate close affinities of *T. gigantea* with *T. circularis* (Chaney) Meyer et Manchester of the Oligocene in western North America (Hably *et al.* 2000). Leaves of *T. gigantea* are dispersed in most of the volcanogenic floras in northern Bohemia and adjacent Seifhennersdorf ("*Tilia irtyschensis*" sensu Walther 1964, pl. 24, fig. 2).

Craigia bronnii (Unger) Z. Kvaček, Bůžek et Manchester
Pl. 5, fig. 4

Material: 5 fruit valves.

Isolated valves of *Craigia* are typical fossils in many post-Eocene floras in Europe including České Středohoří Mts. This plant arrived to Europe probably from the Arctic regions because it is spread there even in the Eocene (Spitsbergen, Kamchatka and Far East – Kvaček 1994). Like at Holý Kluk, these fruits are associated with the leaves of the *Dombeyopsis*-type also elsewhere in Europe (see below).

Dombeyopsis lobata Unger
Pl. 5, fig. 2

Material: 3 leaf fragments.

Several fragmentary specimens of this trilobate (rarely simple) leaf form (including *D. dechenii* Weber – see, e.g., Walther 1996) have been recovered. They safely document this previously often misinterpreted foliage, which regularly accompanies *Craigia* fruits (see Knobloch, Kvaček 1965; Kvaček 1993; Akhmetiev, Kvaček, Manchester in progress) and obviously belongs to the same plant. Its autecology must have been wide because it occurred in purely mesophytic assemblages (Bechlejovice, Holý Kluk) but also entered swamp forests (Kvaček, Hurník 2000; Sakala 2000). The extant relatives survived in very limited disjunct areas in southern China and northern Vietnam.

Ulmaceae
Ulmus fischeri Heer
Pl. 6, fig. 2

Material: 1 leaf fragment.

Elm foliage from Holý Kluk matches in all details (broad lamina, coarsely simple-double serrate margin) the other records of the North Bohemian volcanic floras (e.g., Kundratice, Bechlejovice). Kvaček and Walther (1998) suggest *U.* (sect. *Blepharocarpus* Dum.) *americana* L. (syn. *U. alba* Raf.) of eastern North America to be the nearest living relative.

Zelkova zelkovifolia (Unger) Bůžek et Kotlaba
Pl. 5, figs. 6–7, pl. 6, fig. 1

Material: 128 leaves and foliage shoots including several fruiting twigs.

Leaf remains of this tree, but even fruit-bearing ultimate twigs, deciduous at maturity, have been recovered in large quantity and higher morphological variation, like at Suletice-Berand (Kvaček, Walther 1995, text-fig. 3). They do not differ in any respect from those from Kundratice (Kvaček, Walther 1998) and corroborate one of the earliest records of this genus on the Eurasian continent. This fossil population differs by the larger entire part of the leaf base from the three relictual South European – Caucasus species *Z. carpinifolia, Z. cretica* and *Z. sicula.*

Celtidaceae
Celtis sp.
Pl. 6, figs. 5–7

Material: 4 leaves and leaf fragments.

Several leaves of a probably new species of nettle tree differ from the common *C. begonioides* Goeppert by a less asymmetrical and broad leaf base and widely diverging basal secondaries. More similar are the records of the foliage from Rott (Weyland 1937, 1938) and Hrazený (Knobloch 1961) showing similar semicraspedodromous venation. We agree with Knobloch (1961) to exclude *Celtis bohemica* Engelhardt (1898) based on a single leaf from Suletice-

-Berand (re-figured as *Celtis* sp. in Kvaček, Walther 1995, pl. 3, fig. 6) from safe records of *Celtis* on account of differences in the course of the secondary and tertiary venation. Kvaček and Walther (1995) overlooked this fact when they revisited this flora. True *Celtis* is also known from Seifhennersdorf (Walther 1996) and Kleinsaubernitz (Walther 1999).

Hydrangeaceae
Hydrangea microcalyx Sieber
Pl. 6, fig. 10

Material: 5 isolated flowers.

Several quadrimerous petaloid calyces (sepals length ca. 10 mm) match in all characters with the record from Suletice-Berand (see Kvaček, Walther 1995, pl. 7, fig. 5). These above-mentioned forms (also at Hammerunterwiesenthal – Walther 1998, text-fig. 2/20) may turn not to be specifically different from *Hydrangea microcalyx* Sieber (1881) from the Late Eocene type locality of Kučlín (Mai 1985), as it has become apparent from new collections at Kučlín. Mai (1985) assigned a larger specimen with more roundish sepals from Seifhennersdorf to the Late Miocene *H. membranosa* (Goeppert) Mai. The foliage, which is so far unknown in associated leaf assemblages, would certainly help in species differentiation of fossil hydrangeas.

Rosaceae
Rosa lignitum Heer
Pl. 6, figs. 3–4

Material: 16 isolated leaflets and 1 twig.

A few leaflets and a thorny twig belong apparently to this common element of the volcanic floras (see Kvaček, Walther 1998). It occurs rarely in the Early Oligocene lowland floras in the Haselbach Floral Assemblage (Mai, Walther 1978).

Leguminosae
Mimosites haeringianus Ettingshausen
Pl. 6, fig. 9

Material: 35 isolated leaflets and one fragmentary leaf.

Typical narrow leaflets of this Palaeogene legume can hardly be mistaken for another taxon. They were widespread in volcanic floras, at Kundratice also as several complete compound leaves (Engelhardt 1885).

Leguminosites spp.
Pl. 6, fig. 8, pl. 11, figs. 5–6

Material: 35 isolated leaflets and one fragmentary pod.

Elliptical leaflets of different size categories (i.e., obviously belonging to several taxa) have been rarely encountered at Holý Kluk, contrary to Suletice-Berand, where legumes are diversified and abundant. A single fragmentary pod has been found in association.

Rutaceae
cf. *Zanthoxylum* sp.
Pl. 7, fig. 1

Material: 1 leaf fragment.

A small fragment of a compound leaf with the narrowly alate rachis and few narrow elliptic sessile opposite leaflets may indicate a new record of *Zanthoxylum* L. Due to its poor preservation, the value of this fossil is rather low. The recovered fragment is obviously a topotypical specimen of *Weinmannia glabroides* Engelhardt (1876), described on the basis of the collection of Castelli, now missing. Similar leaf fossils have been described in Europe as *Zanthoxylum europaeum* Unger (e.g., Unger 1847, Radoboj, Middle Miocene, Givulescu, Rüffle 1986, Minişu de Sus, Middle Miocene) or *Weinmannia europaea* (Unger) Ettingshausen (e.g., Kräusel 1938, Mainz-Kastel, lowermost Miocene). An affinity to Cunoniaceae, as suggested by Ettingshausen (1854), seems rather improbable due to biogeographic reasons (see also Givulescu, Rüffle 1986). The genus *Zanthoxylon* is safely documented by fruit remains from various sites of the European middle and late Tertiary (Mai 1995) and fits also in the vegetation type reconstructed for Holý Kluk (see below).

Aceraceae
Acer cf. *angustilobum* Heer
Pl. 7, figs. 2–3

Material: 43 leaf impressions.

Leaves trilobate, petiolate, up to 90 mm large, with slender, irregularly dentate lobes (for more details see Walther 1972; Procházka, Bůžek 1975 – as *A. dasycarpoides* forma *angutilobum*).

This species is an important accessory element in the volcanic floras (Kvaček, Walther 1995, 1998; Walther 1972, 1996). *A. angustilobum* prevails at some localities (e.g., Kundratice) and is connected with *Acer dasycarpoides* by transition forms with more distinctly dentate margin. It is therefore uncertain, whether all specimens without epidermal structure belong to this species.

Acer cf. *engelhardtii* Walther
Pl. 8, fig. 1 right

Material: 1 leaf impression.

Leaf fragment trilobate, medial lobe much longer than the side lobes, irregularly dentate, side lobe triangular, rarely dentate.

Such a type of maple leaves occurs only sporadically in the volcanic floras of Seifhennersdorf (Saxony) and Kundratice (Early Oligocene). Only a single leaf was found in the Early Miocene Břešťany (Preschen) Clay in the North Bohemian Lignite (Most) Basin of the Bílina area. Walther (1972) published the first records of this species including anatomical characteristics. *Acer haselbachense* is similar in the papillate surface of the abaxial epidermis, but many simple-celled bases of trichomes cover the adaxial epidermis. Without these important characteristics it is impossible to identify safely such leaf impressions.

Acer pseudomonspessulanum Unger
Pl. 8, fig. 7

Material: 3 leaf impressions.

Leaves trilobate, fragmentary, about 50 mm long, entire margined, with a small tooth only on the basal part of the side lobe.

Such nearly entire-margined trilobate maple leaves occur very rarely in the volcanic floras, e.g. at Seifhennersdorf (Walther 1967), Suletice-Berand (Kvaček, Walther 1995)

and Kundratice (Kvaček, Walther 1998). From the first two localities these leaf forms were described as *Acer loclense* Hantke (Walther 1967) and *Acer* cf. *decipiens* A. Braun (Kvaček, Walther 1995). We accept the concept of this fossil species given by Walther (1972 – as *A. decipiens*) in view of new studies on fossil maples (Stroebitzer-Hermann, personal communication in 2001).

Acer palaeosaccharinum Stur
Pl. 8, figs. 4–5

Material: 45 leaf impressions.

Leaves tri- to quinquelobate, coarsely and sharply dentate, medial lobe narrowed towards its base. More or less typical are the pairs of tooth-like lobes. Leaf size and form rather variable, like in other occurrences (e.g., Walther 1972; Kvaček, Walther 1998).

This species shows similarities in gross morphological architecture with *Acer haselbachense* Walther (1972), but the papillate leaf abaxial side characterizes the latter. In the material of the Kleinsaubernitz core near Bautzen (Saxony), maple leaves of similar morphology and also papillate, and hence assigned to *Acer haselbachense*, represent the first record in the volcanic floras (Walther 1999). Both species of maples may be interpreted as a parallel evolution (Kvaček, Walther 1995). On the other hand, it is not clear, if *Acer palaeosaccharinum*, originally known from the Neogene of Austria (Stur 1867), belongs to the same taxon as the leaves from the Oligocene volcanic floras. This problem needs a further detailed research work.

Acer cf. *tricuspidatum* Bronn
Pl. 8, figs. 2–3

Material: 22 leaf impressions.

Leaves mostly trilobate, rarely quinquelobate. Gross morphology and marginal dentation correspond generally to the characteristics given by Walther (1972).

In the volcanic floras the leaves of this maple differ noticeably from the type collections at Salzhausen in the dentation and in the wide angle of lobes (e.g., Seifhennersdorf – Walther 1964, 1996; Kundratice – Kvaček, Walther 1998; Kleinsaubernitz – Walther 1999). It is difficult to determine fragmentary leaves without cuticular remains. Considering the high range of distribution of *Acer tricuspidatum* (Oligocene to Pliocene), this wellknown Tertiary maple may include some more subspecies besides *A. tricuspidatum* ssp. *lusaticum* Walther (in Mai, Walther 1988). It seems likely that the leaves from the volcanic floras also represent an independent subspecies. But this idea can only be proved by a detailed study of more abundant and better preserved material.

Acer spp.
Pl. 7, figs. 5–6, pl. 8, figs. 6, 8

Material: about 15 specimens of fruits.

Several forms of detached winged samaras of maples occur in the association of the above-described leaves. Their taxonomic determination is hardly possible due to poor preservation and lack of endocarp characters. Mere morphology of impressions does not allow employing the species concepts given by Mai (1995).

Simaroubaceae
cf. *Ailanthus prescheri* Walther
Pl. 9, fig. 1

Material: 7 leaflets.

Similar leaflets with long petiolules and typically widely simple dentate margins occur often in volcanic floras not only in northern Bohemia, but also in Germany (see Walther 1999). We assume that they belong to a single distinct species. More data on epidermal anatomy are needed to be absolutely sure about the status of this taxon.

Cornaceae
Cornus studeri Heer
Pl. 9, figs. 2–3

Material: 41 leaf impressions.

Such leaves showing a typical cornoid, camptodromous venation are traditionally assigned to *Cornus* L. sensu lato. They match similar records occurring at Kundratice (Kvaček, Walther 1998, pl. 4, fig. 9) and elsewhere in the Oligocene of central Europe.

Icacinaceae
Palaeohosiea suleticensis Z. Kvaček et Bůžek
Pl. 9, fig. 5

Material: 1 specimen.

One endocarp (mold) of this species has been found in a tuffitic layer at Holý Kluk and corresponds exactly with the type collection from Suletice, the test pit S-2 (Kvaček, Bůžek 1995). It is highly probable that also the records from Haselbach and Seifhennersdorf (as *Hosiea bilinica* (Ettinsgshausen) Holý in Mai et Walther 1978 and *Prunus bilinica* (Ettingshausen) Mai 1963, respectively) belong to the same species. The endocarps of this certainly very thermophilic, extinct (or morpho-) taxon are superficially more similar to those of the recent *Iodes* Blume (tropical Africa, Madagaskar, Indomalaysia, southern China, Hainan) than of *Hosiea* Hemsl. et Wils. (western and central China, Japan); and only the position of the funicular canal within the endocarp, which is not clear in the fossil at hand, would solve this question (Manchester 1999). The leaves suspected to belong to *Palaeohosiea* fruits by Kvaček and Bůžek (1995 – as *Icaciniphyllum*) have been recently recognised as foliage of *Sloanea* (Kvaček, Hably, Manchester 2001). Because of the growth habit of Icacinaceae tribe Iodeae – lianas – the corresponding foliage may not occur very frequently in the association, as it is the case in other lianas (e.g., *Smilax,* Menispermaceae). From the local plant assemblage of Holý Kluk, two fragmentary leaves (see below under *Dicotylophyllum* spp. – pl. 2, fig. 3 right, pl. 11. fig. 7) show gross morphological characters of *Iodes* and may belong to the same plant as the fruit of *Palaeohosiea suleticensis*.

Vitaceae
Ampelopsis hibschii Bůžek, Z. Kvaček et Walther
Pl. 9, figs. 6–7

Material: 35 leaf impressions.

Leaves/leaflets with a coarsely dentate margin and the typically half-separated leaf apex are easily recognisable even in the fragmentary state of preservation. Judging according to the corresponding leaf morphology and

anatomy, the populations from the Oligocene of the České Středohoří Mts. are closely allied and specifically identical to that from Haselbach (Bůžek, Kvaček, Walther 1981).

Ampelopsis cf. *rotundata* Chandler
Pl. 9, fig. 4, pl. 10, fig. 5

Material: 3 seeds (with counter-impressions).

Molds of seeds belonging to Vitaceae accompany the leaves of *Ampelopsis hibschii* at Holý Kluk. In spite of the poor preservation, their obovate-roundish shape, the absence of radial grooves, and the subcentral to marginal chalaza, suggest *A. rotundata*, according to the key in Mai (1999). Their bigger size (4–5 mm) is obviously due to the preservation mode as molds (while carbonized fossils may loose the original size due to shrinking). They match well the seeds described from Haselbach as *Ampelopsis rotundata* (Mai, Walther 1978). Because of this co-occurrence at two places – Holý Kluk and Haselbach, we assume that these two taxa, *A. hibschii – A. rotundata*, may belong to the same plant (see also Bůžek *et al.* 1981).

familia dubia
cf. "*Viburnum*" *atlanticum* Ettingshausen
Pl. 10, fig. 3

Material: 1 leaf fragment.

A small fragmentary ovate leaf is noteworthy because of the rather finely crenulate margin and the fine tertiary venation oblique to the secondaries. Such leaf forms have been usually assigned to "*Viburnum*" *atlanticum* Ettinsgshausen sensu Bůžek (1971). However, typical glandular teeth are not seen in our material and this suggests that this entity may not be quite homogenous.

"*Rhus*" *pteleaefolia* Weber
Pl. 10, fig. 1

Material: 1 leaf impression.

A single leaf with the acuminate apex and the regular, brochidodromous venation can be assigned to the above morpho-taxon. Its affinities are entirely obscure. A similar fragmentary leaf, but with a longer acuminate apex, was described from the Hrazený hill (Knobloch 1961).

"*Acer*" *sotzkianum* Unger
Pl. 10, figs. 4, 7

Material: 1 fruit.

The figured single fragmentary fruit matches *Acer sotzkianum* Unger, a rare species first described from the Lower Oligocene (? Upper Eocene) of Socka (Unger 1850), and later, as the fruits of *Acer crassinervium* Ettinsghausen, from the Upper Eocene of Kučlín (Ettinsgshausen 1869). Mai (1999) stresses the affinity of these fruit remains to *Acer* sect. *Negundo* (Boehm.) Maxim. However, the fruits seem not to be double samaras of the *Acer* -type. In our specimen and also some others newly recovered at Kučlín (Kvaček 2002), an attachment scar between two partial samaras is not visible. On the contrary, a simple short process suggesting the attachment to a simple stalk is exceptionally preserved. Therefore, we hesitate to accept this very distinct type of fruits as an unequivocal evidence of the maple.

Apocynospermum striatum Reid et Chandler
Pl. 10, fig. 9

Material: 2 seeds.

This type of narrow elliptic seeds with an apical pappus has been found so far at many sites of the České Středohoří Mts. (see Kvaček, Walther 1998) and also elsewhere in Europe. Before its affinities are definitely solved we range these fossil seeds into 'incertae sedis', even though they may really turn to be remains of Apocynaceae. Noteworthy is their very scanty occurrence, never in higher frequency at one site. Also the nomenclature, particularly priority problems, have to be solved in future studies.

Saportaspermum sp.
Pl. 11, fig. 4

Material: 1 seed (with counter-impression).

A winged seed is obviously one of the records of *Saportaspermum* Meyer et Manchester (1997), distributed in the Oligocene and Miocene of Europe. A more precise evaluation of these so far enigmatic seed remains is badly needed. Similar seeds of *Calocedrus* show a narrow triangular projection of the seed into the wing (see above under *Calocedrus suleticensis*).

Oleinites maii (Bůžek, Holý et Z. Kvaček) Sachse
Pl. 10, fig. 10

Material: 3 leaf impressions.

Some entire, broadly elliptic leaves with peculiar dense secondaries-intersecondaries can be safely assigned to the above morpho-species. According to Sachse (2001), its epidermal anatomy, particularly in the kind of trichomes, is in many respects similar to Oleaceae.

Dicotylophyllum deichmuelleri Z. Kvaček et Walther
Pl. 10, fig. 8

Material: 9 leaf impressions.

Identical simple broadly ovate widely and bluntly dentate leaves with the dense semicraspedodromous venation were described as a new species of doubtful affinities from the Kundratice flora (Kvaček, Walther 1998). In spite of the known epidermal anatomy, its exact systematic position has not been clarified.

Dicotylophyllum heerii (Engelhardt) Z. Kvaček et Walther
Pl. 10, fig. 2

Material: 2 leaf impressions.

Identical elongate, finely crenulate leaves occur abundantly in the Kundratice flora (Kvaček, Walther 1998). Also in this case, the exact systematic position has not been clarified in spite of the available epidermal anatomy.

Dicotylophyllum sp. div.
Pl. 2, fig. 3 right, pl. 11, fig. 7

Material: 52 leaf impressions.

There are many enigmatic dicot leaves, partly of fragmentary nature and the poorly preserved venation, which are enumerated here. One characteristic form represented by two broadly ovate fragmentary leaves with a typical asymmetry of the base and a long petiole recalls the foliage of *Iodes* and may belong to the same plant as the endocarp of associated *Palaeohosiea* (see above). Due to the

fragmentary nature and the poor preservation, this is only a very tentative speculation.

Antholithes sp.
Pl. 11, figs. 1–3

Material: 1 flower (with counter-impression).

A stalked quadrimerous flower with the persistent calyx shows no remains of a carpel nor stamens. The sepals 5 mm wide and 8 mm long are obovate, apiculate, with faintly visible three sub-parallel veins. The overall morphology corresponds to a sterile, laterally compressed flower of *Hydrangea*, but in view of apparent differences in sepal venation and the cup-like form we hesitate to include it directly into the above described *H. microcalyx*. Still more similar are laterally compressed specimens of the so-called *Porana oeningensis* Heer (1859, pl. 103, fig. 24a), usually preserved as spread pentamerous perianths occurring at the Middle Miocene locality Oehningen, but also in the Early Miocene Břešťany Clay of the Most Basin. The poor preservation of the venation prevents us to be sure even about the latter alternative.

Carpolithes sp. div.
Pl. 7, fig. 4

Material: ca. 10 specimens.

Several fruit and seed fossils have been found. Some of them are worth further studies for their safe identification. One specific type of branched infructescences is figured as an example. It was encountered also at Kundratice (Engelhardt 1885, pl. 8, fig. 15 – as an inflorescence of *Viburnum atlanticum* Ett.; Radoň 2001, p. 148), but its affinities remain dubious in view of inadequate preservation.

Smilacaceae
Smilax weberi Wessel
Pl. 10, fig. 6, pl. 11, fig. 5.

Material: 6 leaf impressions.

The recovered fragmentary leaves with the venation of the *Smilax*-type can be compared with similar leaf impressions assigned to the above morpho-species (see, e.g., Bůžek 1971). Their determination is based on the material from Rott (Late Oligocene). In the volcanic floras such leaves occur only rarely (e.g., Seifhennersdorf – Walther 1964, 1996, as *S.* cf. *weberi*; Kundratice – Kvaček, Walther 1998, as *Smilax* sp.). One deeply cordate/hastate leaf (pl. 11, fig. 5) is included to this species, following the concept suggested by Bůžek (1971). It may also represent another species or even genus (cf. *Dioscorea*) – see also discussion about similar leaf forms in Ferguson (1971, pp. 269–271).

Monocotyledoneae gen. et sp. indet.

Material: 3 leaf fragments.

Strap-shaped leaves with parallel venation are rare and not determinable due to poorly preserved details.

TAPHONOMY, VEGETATION, ENVIRONMENT AND CLIMATE

The plant assemblage of the Holý Kluk hill comes from the bedded tuffitic claystone with a small proportion of diatoms. Two changing facies can be distinguished – pellitic

Table 1
Tentative revision of the identifications by Engelhardt (1876) according to the published line drawings.

Engelhardt 1876	tentative revision
Libocedrus salicornioides, partim, pl. 4, figs. 4–7	*Tetraclinis salicornioides*
Libocedrus salicornioides, partim, pl. 4, fig. 8	*Calocedrus suleticensis*
Glyptostrobus europaeus, pl. 4, fig. 9	Taxodiaceae gen. et sp. indet.
Callitris brongniartii, partim, pl. 4, fig. 10	*Calocedrus suleticensis*
Callitris brongniartii, partim, pl. 4, fig. 11	*Tetraclinis salicornioides*
Smilax obtusata, pl. 4, fig. 12	*? Smilax weberi*
Populus mutabilis, partim, pl. 4, figs. 13, 15	*Cornus studeri*
Populus mutabilis, partim, pl. 4, fig. 14	*Ampelopsis hibschii*
Salix varians, pl. 4, fig. 16	*? Carya serrifolia*
Myrica lignitum, pl. 4, figs. 21–22	*Engelhardia orsbergensis*
Myrica hakeaefolia, pl. 5, fig. 1	*Engelhardia orsbergensis*
Myrica acuminata, pl. 5, fig. 2	*? Platanus neptuni*
Betula prisca, partim, pl. 5, figs. 3, 5	*Betula* cf. *buzekii*
Carpinus pyramidalis, pl. 5, fig. 8	*Carpinus grandis*
Quercus haidingeri, pl. 5, fig. 12	*Sloanea artocarpites*
Ulmus bronnii, pl. 5, fig. 13	*Craigia bronnii*
Planera ungeri, pl. 5, figs. 14–17	*Zelkova zelkovifolia*
Ficus lanceolata, pl. 5, fig. 19	*? Magnolia* sp.
Cinnamomum rossmaessleri, pl. 5, fig. 20	*Daphnogene cinnamomifolia*
Cinnamomum polymorphum, partim, pl. 6, figs. 1–2	*? Daphnogene cinnamomifolia*
Cinnamomum lanceolatum, pl. 4, figs. 23–25, pl. 5, figs. 21–22	*Daphnogene cinnamomifolia*
Laurus primigenia, pl. 6, fig. 5	*Laurophyllum* sp.
Banksia haeringiana, pl. 6, figs. 6–7	*Engelhardia orsbergensis*
Banksia longifolia, pl. 6, fig. 8	*Engelhardia orsbergensis*
Embothrium salicinum, pl. 6, fig. 12	*? Calocedrus suleticensis*
Lomatia heerii, pl. 3, fig. 14	*Engelhardia orsbergensis*
Ardisia myricoides, pl. 6, fig. 17	*? Carya serrifolia*
Cinchona aesculapi, pl. 6, fig. 15	*? Oleinites maii*
Weinmannia glabroides, pl. 6, figs. 20–22	cf. *Zanthoxylum* sp.
Terminalia radobojana, pl. 6, fig. 13	*Cornus studeri*
Neritinium ungeri, partim, pl. 7, figs. 4–5	*Engelhardia orsbergensis*
Eugenia haeringiana, pl. 6, fig. 26	*Laurophyllum* sp.
Sapindus pythii, partim, pl. 7, fig. 7	*Engelhardia orsbergensis*
Sapindus pythii, partim, pl. 7, fig. 8	*?* cf. *Ailanthus prescheri*
Sapindus pythii, partim, pl. 7, fig. 9	*? Platanus neptuni*
Sapindus falcifolius, partim, pl. 7, fig. 2	*Laurophyllum* sp.
Dodonea salicites, pl. 7, fig. 14	*Craigia bronnii*
Juglans bilinica, pl. 7, fig. 6	*Sloanea artocarpites*
Engelhardtia brongniartii, pl. 7, figs. 30–31	*Engelhardia macroptera*
Acer trilobatum, pl. 7, figs. 17–18	*Acer* cf. *tricuspidatum*
Acer trilobatum, pl. 7, fig. 19	*Acer* sp.
Rhamnus castellii, pl. 7, fig. 20	*Cornus studeri*

Table 1 continued

Engelhardt 1876	tentative revision
Cassia berenices, pl. 7, fig. 21	*Leguminosites* sp.
Cassia lignitum, pl. 7, fig. 22–23	*Leguminosites* sp.
Dalbergia haeringiana, pl. 7, fig. 25	*Leguminosites* sp.
Leguminosites paucinervis, pl. 7, fig. 26	*Leguminosites* sp.
Leguminosites geinitzii, pl. 7, fig. 27	*Leguminosites* sp.
Mimosa haeringiana, pl. 7, fig. 28	*Leguminosites* sp.

Table 2
Floristic comparison between the sites Holý Kluk (taxa printed in bold face – this paper), Suletice-outcrop (including test pit S-2 – Wentzel 1881, Menzel 1897, Kvaček, Bůžek 1995, revised) and Suletice-Berand (Kvaček, Walther 1995, partly revised)
classes of the specimens frequency: I = more than 300, II = 100-299, III = 40-90, IV = 10-39, V = 1-9, + = presence.

Taxon	Holý Kluk	Suletice-outcrop	Suletice-Berand
Acer* cf. *angustilobum	III	+	V
Acer cf. *dasycarpoides*			V
Acer* cf. *engelhardtii	V		
Acer pseudomonspessulanum	V	+	V
Acer palaeosaccharinum	III	+	IV
Acer* cf. *tricuspidatum	IV		IV
***Acer* spp.**	III	+	IV
"Acer" sotzkianum	V		
cf. *Ailanthus prescheri*	V		V
Alnus gaudinii	V	?+	
Ampelopsis hibschii	IV	+	V
Ampelopsis* cf. *rotundata	V	?+	
***Antholithes* sp.**	V		
cf. *Apocynophyllum* sp.			V
Apocynospermum striatum	V	?+	V
Betula* cf. *buzekii	V		?V
Calocedrus suleticensis	III	+	IV
Carpinus grandis	III	?+	IV
Carpinus mediomontana	V	+	V
***Carpolithes* sp.**	IV		V
Carya serrifolia	III	+	IV
***Carya* sp.**	V	+	
***Celtis* sp.**	V		
cf. *Cephalotaxus parvifolia*	V		V
Cercidiphyllum crenatum	IV	+	
Cornus studeri	III	+	IV
Craigia bronnii	V		III
cf. *Cyclocarya cyclocarpa*	IV		V
Daphnogene cinnamomifolia	III	+	III
Dicotylophyllum deichmuelleri	V	+	
Dicotylophyllum heerii	V		
***Dicotylophyllum* spp.**	III	+	V
Dombeyopsis lobata	V	?+	?V
cf. *Dusembaya* sp.	IV		V
Engelhardia macroptera	IV	+	IV
Engelhardia orsbergensis	II	+	V

Table 2 continued

Taxon	Holý Kluk	Suletice-outcrop	Suletice-Berand
***Engelhardia* sp. (amentum)**	V		V
Hydrangea microcalyx	V		V
Laurophyllum* cf. *acutimontanum	V	+	V
Laurophyllum cf. *medimontanum*			V
Laurophyllum cf. *pseudoprinceps*		+	IV
***Laurophyllum* sp.**	I	+	
Laurocarpum sp.			V
***Leguminosites* spp.**	IV	+	III
Liriodendron haueri			V
cf. *Magnolia* sp.	IV		IV
Mahonia sp.			V
cf. *Matudaea* sp.	V		V
Mimosites haeringianus	IV		IV
Monocotyledonae gen. et sp.	V		IV
Oleinites maii	V		IV
cf. *Osmunda* sp.			V
Ostrya atlantidis	IV	?+	V
Palaeohosiea suleticensis	V	+	
"Palaeolobium" sp.			V
Platanus neptuni	IV	?+	II
Polypodium radonii	V		
Populus zaddachii			V
Pronephrium stiriacum			V
Pungiphyllum cruciatum		+	V
"Rhus" pteleaefolia	V		
Rosa lignitum	IV	?+	V
cf. *Rumohra recentior*	V		
***Saportaspermum* sp.**	V		
Sloanea artocarpites	III	+	II
***Sloanea* sp.**	V		V
Smilax weberi	V	+	?V
Tetraclinis salicornioides	III	+	III
Tilia gigantea	V	+	
cf. *Torreya bilinica*	V		
Ulmus fischeri	V	?+	
"Viburnum" atlanticum	V		
cf. *Zanthoxylum* sp.	V		
Zelkova zelkovifolia	II	+	III

claystone with a small content of diatoms and psammitic tuffite without diatoms. In the psammitic tuffite mostly solid fruits (*Carya, Palaeohosiea*), and wood fragments were deposited, rarely foliage in poor state of preservation. In the claystone layers on particular bedding planes, abundant leaf impressions and some winged fruits are concentrated, but plant fossils are dispersed abundantly in the whole claystone. The parts of the claystone layer adjacent to the psammitic tuffite are harder than the rest of the sediment and are usually rich in *Zelkova* and *Acer* foliage together with other arboreal elements. The regular interchange of the two lithofacies (Fig. 2) suggests repeating inflows (psammitic

facies), which brought coarser plant fossils (e.g., endocarps) into the lake, with the following low-energy sedimentation fining upwards. It is noteworthy that a similar series of lignite seamlets and interchanging claystone layers was noticed in the nearby mines at Proboštov and Horní Zálezly and may correspond to changes of water level in the lake and adjacent swamps during the same time interval. A lake with calm waters may be expected as sedimentary environment, which arose during a short period of low volcanic activity in the landscape. Similar intrabasaltic diatomite/tuffite deposits are developed at the nearby sites Suletic-Berand and Suletice, with a higher content of diatoms (Fig. 1). Comparing the two plant lists of Suletice-Berand, Suletice and Holý Kluk (table 2), it becomes evident that both are strikingly similar, almost identical. Although collecting possibilities were limited at all three sites, we suppose a similar vegetation type that surrounded the crater (caldera) lake, which spread between these sites before the intrusion of the trachybasalt bodies. The assemblages largely lack typical azonal elements and hence the same model, as reconstructed for the Suletice-Berand assemblage (Kvaček, Walther 1995), can be applied for Holý Kluk as well. We must only improve the picture by newly acquired information on the taxonomic status of various elements. First the abundant *Sloanea*, a tall tree typical of subtropical and tropical evergreen forests, was misinterpreted for lianas of the Icacinaceae (Kvaček, Bůžek 1995). Yet, a single fruit of *Palaeohosiea* witnesses lianas of this basically tropical family at Holý Kluk. This element, probably allied to the tropical-subtropical liana *Iodes* Blume may indicate quite warm conditions without frost. Among several maples, shared with the other sites of the České Středohoří Palaeogene, a single fragmentary *Acer*-like fruit "*A*". *sotzkianum* deviates from this genus and suggests connection with subtropical vegetation, as at Kučlín and Socka. Several other plant elements, not yet definitely elucidated (like *Oleinites maii, Dicotylophyllum deichmuelleri*) may also contribute to interpretations of vegetation.

The overall aspect of the assemblage (table 3) is surely mesophytic, without representatives of the coal-forming or riparian Taxodiaceae and other azonal elements. Arboreal plants dominate over a few shrubs (*Rosa,* possibly *Cornus, Zanthoxylum*), lianas/vines (*Ampelopsis, Hydrangea, Palaeohosiea, Smilax*) and very scanty (partly epiphytic?) herbs (*Polypodium,* cf. *Rumohra,* Monocotyledonae). The proportion of broad-leaved deciduous elements is considerable (about 60% of arboreal taxa), yet not high enough to rule out subtropical conditions. On the other hand, thermophilic elements, like *Engelhardia, Sloanea, Palaeohosiea*, would hardly survive the coldest month mean temperature below zero. It is probably due to fertile soils in volcanic areas that the evergreen Fagaceae, so typical of subtropical/montane tropical vegetation, are not represented, a question already discussed by Kvaček and Walther (1995, 2001). The forests surrounding the lake formed obviously dense stands on elevated shores close to the place of deposition. Like in Suletice-Berand, we cannot expect a broader belt forming riparian-swamp herbaceous communities around the lake. Obviously the distance of about 3 km between Suletice-Berand and Holý Kluk did not much influence the composition and aspects of vegetation. Both sites must belong to the same period and the same landscape/lake system.

The coal clay facies bound to the uppermost portion of the section at Holý Kluk has not yielded any fossils, like in many other places of the České Středohoří Mts. (e.g., Markvartice). Some Taxodiaceae fossils found in the coal clay tuffite at Horní Zálezly (coll. NM) corroborate that the coal-forming swamp forest consisted mostly of conifers. This type of vegetation strikingly deviates from that found in the fossiliferous layers studied, having been connected with different environment.

Because of very limited amount of specimens, and difficulties to fix the exact number of entire-margined leaf forms we refrained from using the CLAMP analysis and the percentage of entire/dentate broad-leaved taxa. Climatic estimates can also be derived from the co-existence approach (Mosbrugger, Utescher 1997) and from comparisons with the similar extant vegetation and the connected climatic parameters from today.

The vegetation estimated from the list of elements (table 3) matches clearly the transition between subtropical notophyllous evergreen forest on its northern limit, as known in southern China (Fujian, Kweichou, lowlands of Taiwan), and warm-temperate Mixed Mesophytic Forest as defined by Wang (1961). The problem of exact tracing climatic parameters of forest formations is the lack of virgin forests in the lowlands of southern and central China. On the case of the Central-North American vegetation types, it is difficult to find enough corresponding taxa to the Holý Kluk assemblage and to sort out a comparable forest formation (of Florida, Mexico or elsewhere) to estimate analogous climatic conditions.

First-hand comparisons can be made with central southern China and Taiwan, where more thermophilic elements (*Iodes, Calocedrus, Engelhardia, Sloanea*) are intermixed with deciduous typically temperate broad-leaved elements *(Tilia, Acer, Ostrya, Carpinus, Betula* etc.). The co-existence approach does not allow to expect severe cold month means, in spite of the fact that the forests at Holý Kluk were not dominated by evergreen trees. The higher variety of arboreal elements versus shrubs and herbs informs us that the forest canopy should not be open – hence the amount of annual precipitation was high enough to support the complex forest vegetation even under higher mean annual temperature.

The reconstructed forest vegetation as it follows from the list of growth habits and autecology of near relatives of individual components (table 3) can be best compared with the Mixed Mesophytic Forest (two storeys of trees, shrub layer, lianas, and poor herbaceous layer). Particular that kind is similar with higher proportion of woody thermophilic, but also summergreen elements, as it is known on its broad southern contact with evergreen forests in the uplands of southern China, e.g. Omei Opien (see Wang 1961). These patchy remnants of virgine forests of China thrive under conditions approximately corresponding to humide subtropical climate:

MAT 13–18 °C
CMT 2–6 °C
WMT 25–29 °C

Table 3
The assemblage of the Holý Kluk hill arranged according to the model of the vegetation.

taxon	growth form/ foliage	living relative (analogue)	inferred autecology
Platanus neptuni	high tree notophyllous summergreen	? *P. kerrii* (Laos, N. Vietnam)	subtropical
Carya serrifolia	high tree notophyllous summergreen	? *C.* sect. *Apocarya* vel *Sinocarya* (SE N. America, S-E China)	subtropical to warm temperate
Engelhardia macroptera/orsbergensis	high-medium tree microphyllous summergreen	*E.* (sect. *Oreomunnea*) *mexicana* (Mexico-Costa Rica mountains)	subtropical
Zelkova zelkovifolia	medium tree noto-microphyllous summergreen	*Z. carpinifolia* (Caucasus), *Z. cretica* (Creta), *Z. sicula* (Sicily)	subtropical to warm temperate
Ulmus fischeri	medium tree notophyllous summergreen	*U. americana* (USA)	warm temperate
cf. *Ailanthus prescheri*	medium tree notophyllous summergreen	*A. excelsa* (SE. Asia, Australia)	subtropical to warm temperate
Calocedrus suleticensis	medium tree scale-like evergreen	*C. macrolepis* (S. China, Vietnam, Thailand, Burma)	para- to subtropical
Craigia bronnii/Dombeyopsis lobata	medium tree mesophyllous summergreen	*C. yunnanensis* (S. China)	para- subtropical
cf. *Magnolia* sp	medium tree notophyllous summergreen (?)	? *M. denudata* (E.-S. China), *M. salicifolia* (Japan)	subtropical to warm-temperate
Betula cf. *buzekii*	medium tree microphyllous summergreen	? *Betula* spp. (E. Asia)	warm temperate
Alnus gaudinii	medium tree microphyllous summergreen	*A. nitida* (E. Himalaya)	subtropical to warm temperate
cf. *Cyclocarya cyclocarpa*	medium tree microphyllous summergreen	? *C. paliurus* (S. China)	subtropical
Mimosites haeringianus	? medium tree microphyllous summergreen	?	? subtropical
Leguminosae gen. et sp. div.	? medium tree microphyllous summergreen	?	?
Cercidiphyllum crenatum	medium tree microphyllous summergreen	*C. japonicum, C. magnificum* (Japan, C. China)	warm temperate
Tilia gigantea	? medium tree micro- to notopyllous summergreen	? *T. endochrysea, T. tzumu* (S. China)	subtropical to warm temperate
Sloanea artocarpites/S. sp.	? medium tree micro- to notophyllous summergreen	*S. sinensis, S. hemsleyana, S. forrestii* (S.-C. China, Vietnam, Laos)	para- subtropical (-warm-temperate ?)
Tetraclinis salicornioides	? small tree scale-like evergreen	?? *T. verticillata* (W. Mediterranean)	subtropical
Daphnogene cinnamomifolia	medium to small tree noto- to microphyllous evergreen	*Camphora officinalis* (S.-C. China, Japan)	subtropical to warm temperate
Laurophyllum spp.	medium to small tree noto- to microphyllous evergreen	Lauraceae gen. ?	? subtropical
Celtis sp.	medium to small tree noto- to microphyllous summergreen	? *C.* spp. (E. Asia)	subtropical to temperate
Acer spp.	medium to small tree noto- to microphyllous summergreen	*A.* spp. (Asia – N. America)	(subtropical to) temperate
cf. *Matudea menzelii*	small tree noto- to microphyllous evergreen	? *M. trinervia* (Mexico, C. America)	(upland tropical to) subtropical (to ? warm temperate)
Cornus studeri	medium to small tree noto- to microphyllous summergreen	*C.* spp. (Asia and C.-N. America)	(subtropical to) temperate
Carpinus mediomontana/C. grandis	medium to small tree noto- to microphyllous summergreen	*C. turczaninovii* (N.-W. China), *C. orientalis* (S. Europa – Near East)	(subtropical to) warm temperate
Ostrya atlantidis	medium to small tree noto- to microphyllous summergreen	*O.* spp. (C.-southern N. America, S. Europe – Near East, E. Asia)	subtropical to warm temperate
cf. *Cephalotaxus* sp.	medium to small tree needle-like evergreen	*C.* spp. (E. Asia)	subtropical to warm temperate
cf. *Torreya bilinica*	medium to small tree needle-like evergreen	*T.* spp. (E. Asia and North America)	subtropical to warm temperate
cf. *Zanthoxylum* sp.	small tree to shrub microphyllous ? summergreen	Z. spp. (Japan, China)	subtropical to warm temperate

Table 3 continued

taxon	growth form/ foliage	living relative (analogue)	inferred autecology
Rosa lignitum	shrub microphyllous summergreen	*R.* spp.	subtropical to warm temperate
Hydrangea microcalyx	shrub or liana microphyllous summergreen	*H.* spp.	subtropical to warm temperate
Smilax weberi	liana noto- microphyllous evergreen	*S.* spp.	(tropical-) subtropical to warm temperate
Palaeohosiea suleticensis	liana ? noto- microphyllous summergreen	? *Iodes* spp.	para- subtropical
Ampelopsis hibschii/A. cf. *boveyana*	vine notophyllous summergreen	*A.* spp. (southern N. America, E. Asia)	subtropical to warm temperate
cf. *Rumohra recentior*	herb terrestrial fern-like summergreen	? *Rumohra* (S. Hemisphere) vel *Arachnoides* (SE Asia)	? tropical to warm temperate
Polypodium radonii	herb terrestrial or epiphytic fern-like evergreen	*P. vulgare* complex (extratropical Eurasia, Azores, Canary Isl., N. America, Hawaii)	subtropical to temperate
Monocotyledonae gen. et sp.	herbs monocot-like summergreen	?	?
cf. *Dusembaya* sp.	aquatics ? ? summergreen	?	?

MAP 1200–1500 mm

Climatic type according to Köppen – Cfa.

Similar conditions can be anticipated for Oligocene forests at Holý Kluk. The climatic proxies given by the CLAMP analysis (Soukupová 2004) are slightly colder: MAT 11–13.5 °C, CMT -1–2.5 °C, WMT 23–26.5 °C. Although Kvaček and Walther (1995) refrained from indicating climatic estimates in the case of Suletice-Berand, the above-suggested regime of temperature and precipitation applies, due to a very similar plant assemblage, as well for this site. The data for Bechlejovice are also similar (see Kvaček and Walther 2004).

CORRELATION AND DATING

Kvaček and Walther (2001) estimated the plant assemblage of Suletice-Berand as contemporaneous with that of Markvartice, and assigned both to later phases within the Oligocene sequence of the České Středohoří Mts. After consultations with V. Cajz we must correct this assumption, at least for the Suletice-Berand and Holý Kluk sites. The intrusion of trachybasalt at Holý Kluk has been dated to 30.9±1.0–1.5 MA by K. Balogh, Debrecen (J. Ulrych, personal communication), while the basanite underneath the fossiliferous diatomite of Suletice was dated to 28.3±1.4 MA (Bellon *et al.* 1998). These two data tell us that the layer at Holý Kluk was deposited surely before the intrusion. It must be older than 30.9 minus 1.5 MA and 30.9 plus 1.5 MA, i.e. between 29.4–32.4 MA. The layer at Suletice-Berand, which appears contemporaneous according to the flora composition, must be younger than 30.9±1.0–1.5 MA (i.e. 26.9–29.4 MA). Hence an age of about 29–30 MA can be estimated for the Holý Kluk and Suletice sites from the above radiometric data. This level is only slightly younger than the site of Kundratice (this fossiliferous shale and diatomite is older than 32.7±0.8 MA teste Bellon *et al.* 1998) and expresses a warming trend still within Early Oligocene, i.e. during the deposition of the Ústí Formation in sense of Cajz (2000). The similarity of the Kundratice and Holý Kluk floras in higher number of common elements, i.e. *Ampelopsis hibschii, Sloanea artocarpites, Platanus neptuni, Cornus studeri, Rosa lignitum, Mimosites haeringianus, Zelkova zelkovifolia, Ailanthus prescherii, Dicotylophyllum deichmuelleri, D. heerii, D. maii, Acer* spp., etc. corroborates this assumption. Abundant representation of *Engelhardia,* and re-appearance of other Late Eocene "Kučlín" plants, like *Sloanea, Palaeohosiea,* and "*Acer*" *sotzkianum* stress the warming trend at the levels of Holý Kluk (and Suletice-Berand). But we are not sure that the same time slice includes the Markvartice assemblage, where the last two mentioned elements are lacking and *Engelhardia* is scarcely represented. On the other hand, palm foliage, not known in the mentioned Early Oligocene floras of the České Středohoří Mts., has been recovered at Markvartice (E. Knobloch, personal communication) as a new element. Still more complete palm leaves have been recovered recently in a gallery by the first author (M.R.) at Malá Veleň (Radoň 2000, 2001). Unfortunately, no radiometric data are so far available from Markvartice and Malá Veleň to solve the exact correlation with Holý Kluk.

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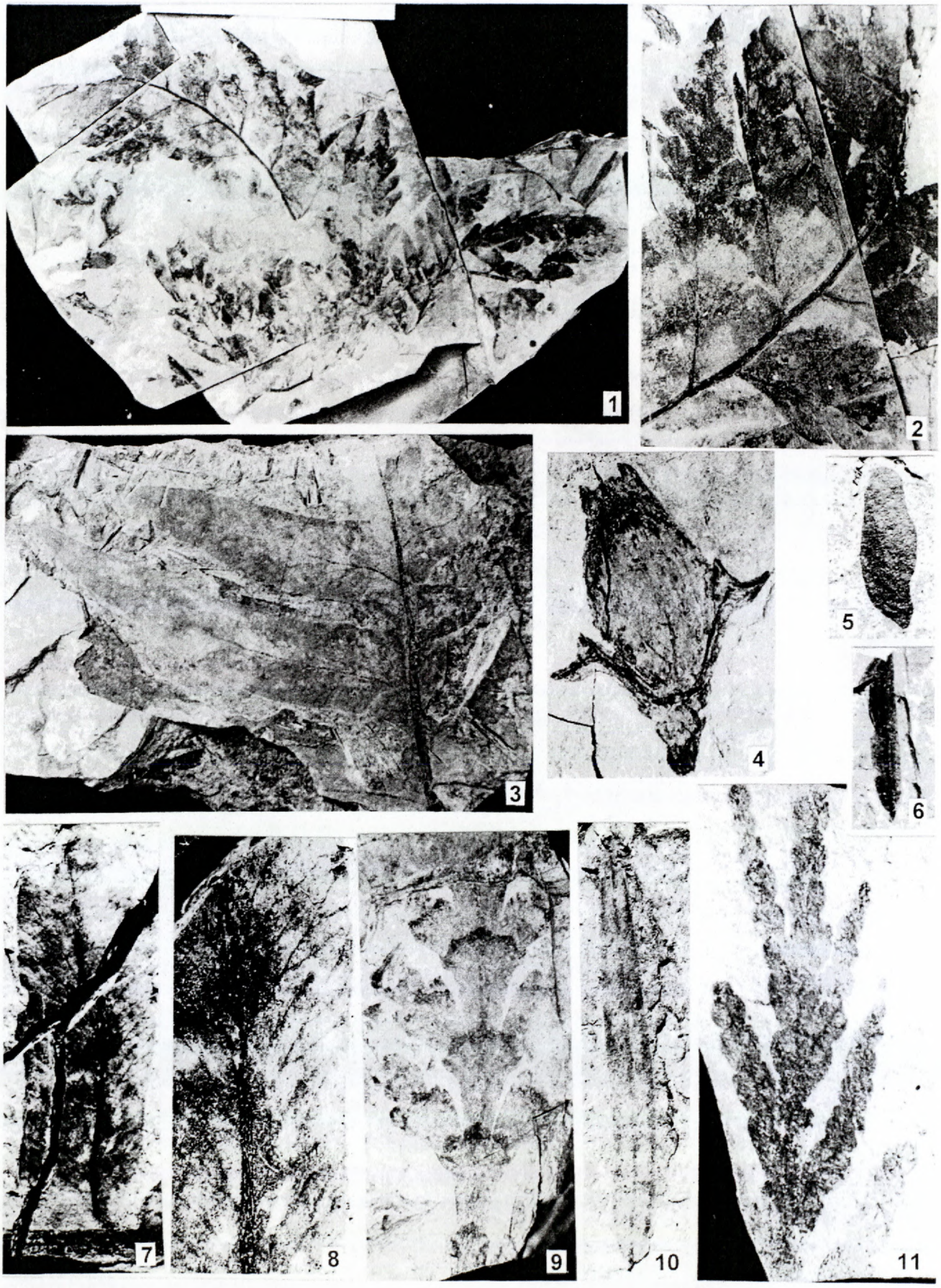


Plate 1

1–2 – cf. *Rumohra recentior* (Unger) Barthel, PA 1114, 1 – x 0.8, 2 – x 3,
3, 7–8 – *Polypodium radonii* Z. Kvaček, 3 – PA 457, x 2; 7 – PA 1070, x 3;
8 – same specimen, x 7.5,
4–5, 11 – *Calocedrus suleticensis* (Brabenec) Z. Kvaček, 4 – seed, PA 976, x 4; 5 – seed cone, PA 977, x 4; 11 – twig, PA 500, x 3,
6 – cf. *Cephalotaxus parvifolia* (Walther) Z. Kvaček et Walther, PA 1083, x 1.7,
9 – *Tetraclinis salicornioides* (Unger) Z. Kvaček, PA 442, x 3,
10 – cf. *Torreya bilinica* Saporta et Marion, 7 – PA 1128, x 2.



Plate 2

1 – cf. *Magnolia* sp., PA 1085b, x 1.3,
2 – *Laurophyllum* cf. *acutimontanum* Mai, PA 1085a, x 1.3,
3 – *Laurophyllum* cf. *acutimontanum* Mai (left), *Dicotylophyllum* sp. (cf. *Iodes*) (right), PA 1082b–c, x 1.3,
4 – cf. *Dusembaya* sp., PA 1078, x 3,
5, 8 – *Cercidiphyllum crenatum* (Unger) R. Brown, 5 – fruits, PA 445, x 4; 8 – leaf, PA 465, x 2,
6 – *Laurophyllum* sp., PA 506, x 1.6,
7 – *Daphnogene cinnamomifolia* (Brongn.) Unger, PA 502, x 1.6.

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Plate 3

1–3 – *Platanus neptuni* (Ettingshausen) Bůžek, Holý et Z. Kvaček, 1 – leaf, PA 491, x 1.2; 2 – stalked pistillate inflorescence, PA 1125, x 3; 3 – infructescence, PA 1126, x 3.5,

4, 13 – *Ostrya atlantidis* Unger, 4 – fruit, PA 1127/1, x 3, 12 – leaf, PA 471, x 2,

5–6 – *Carpinus mediomontana* Mai, 5 – PA 1090/1, x 1.7; 6 – PA 1090/3, x 1.7,

7 – cf. *Matudaea menzelii* Walther, PA 463, x 2,

8 – *Betula* cf. *buzekii* Z. Kvaček et Walther, PA 507, x 1.7,

9 – *Carya* sp., endocarp, PA 1118, x 1.5,

10–11 – *Alnus gaudinii* (Heer) Knobloch et Z. Kvaček, PA 456, 10 – x 1.5; 11 – x 3,

12 – *Carpinus grandis* Unger, PA 501, x 2.

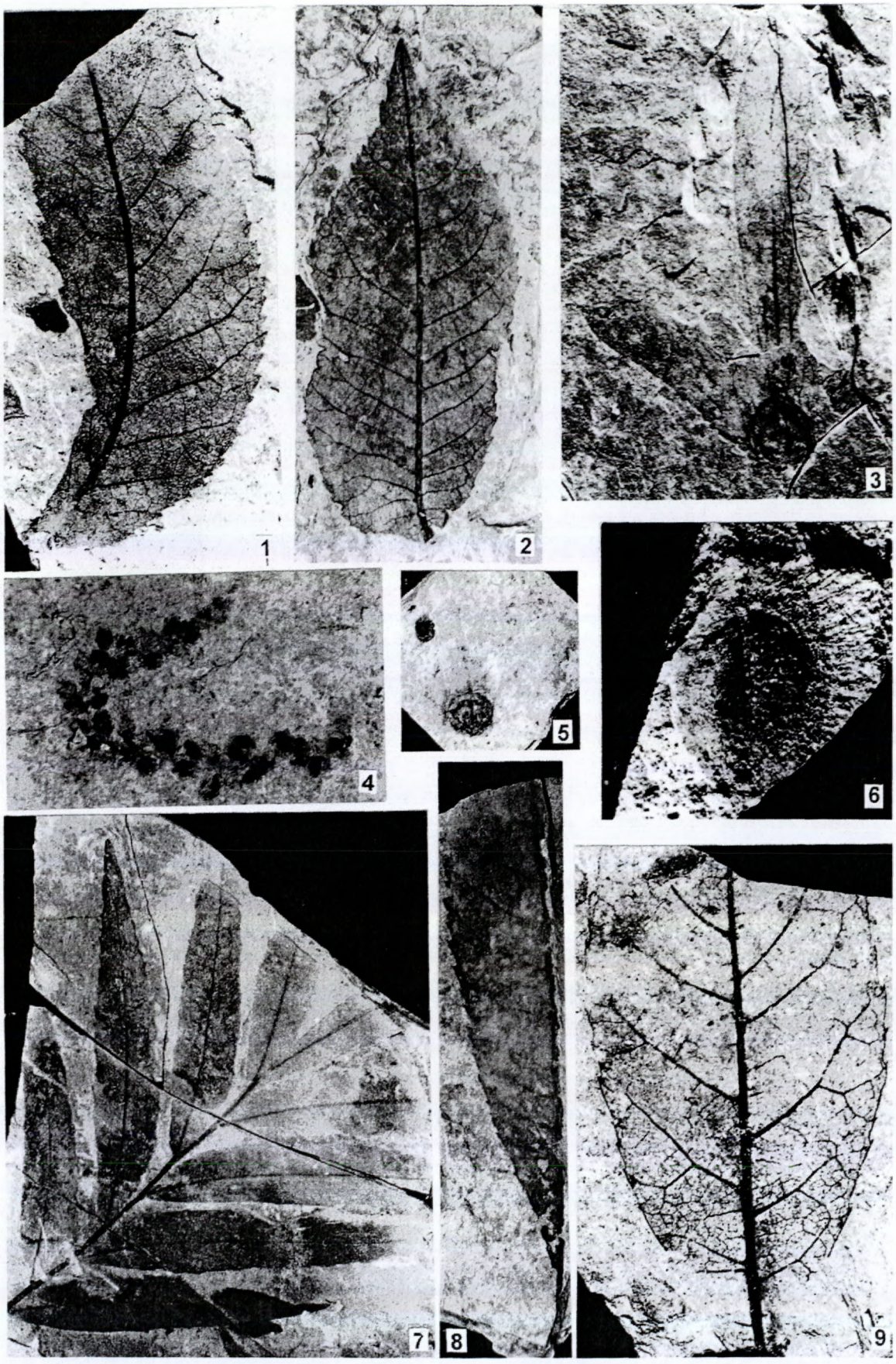


Plate 4

1–2 – *Carya serrifolia* (Goeppert) Kräusel, 1 – PA 1103, x 2.8; 2 – PA 1113, x 2,
3, 5 – *Engelhardia macroptera* (Brongniart) Unger, 3 – PA 1104 c, x 2.6; 5 – PA474, x 2,
4 – *Engelhardia* sp., catkin, PA 1116, x 3,
6 – *Sloanea* sp., fruit valve, PA 1068, x 2.5,
7 – *Engelhardia orsbergensis* (Weber) Jähnichen, Mai et Walther, private coll. Radoň, x 0.8,
8 – cf. *Cyclocarya cyclocarpa* (Schmalhausen) Knobloch, PA 490, x 1.4,
9 – *Sloanea artocarpites* (Ettingshausen) Z. Kvaček et Hably, PA 1071a, x 1.7.

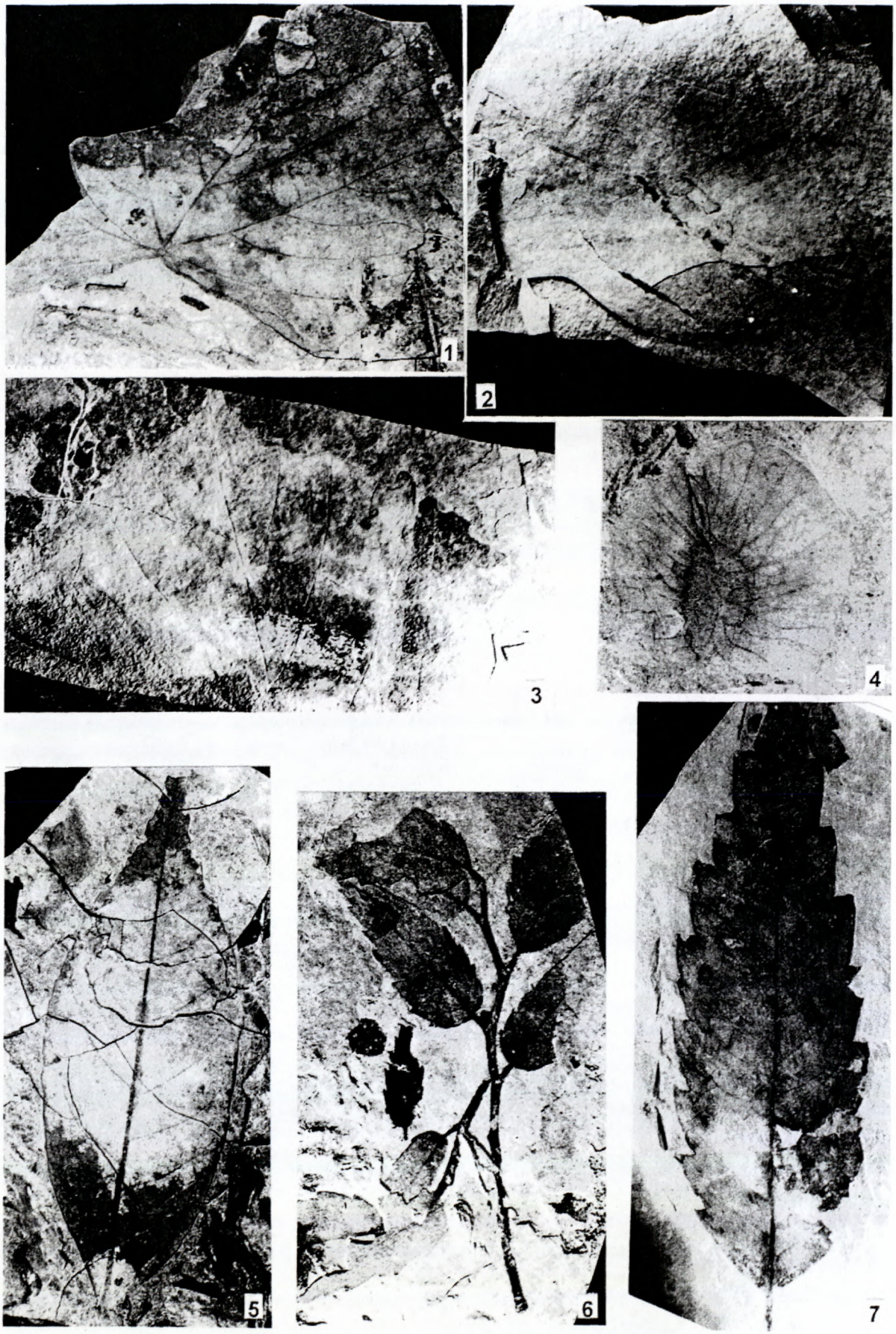


Plate 5

1, 3 – *Tilia gigantea* Ettinsgshausen, 1 – PA 499, x 1.2; 3 – PA 1091/3, x 1.0,

2 – *Dombeyopsis lobata* Unger, PA 504, x 0.9,

4 – *Craigia bronnii* (Unger) Z. Kvaček, Bůžek et Manchester, PA 451, x 4,

5 – *Sloanea arctocarpites* (Ettingshausen) Z. Kvaček, Hably et Manchester, PA 485, x 1.2,

6–7 – *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba, 6 – PA 1096/1, x 2; 7 – private coll. Radoň, x 2.

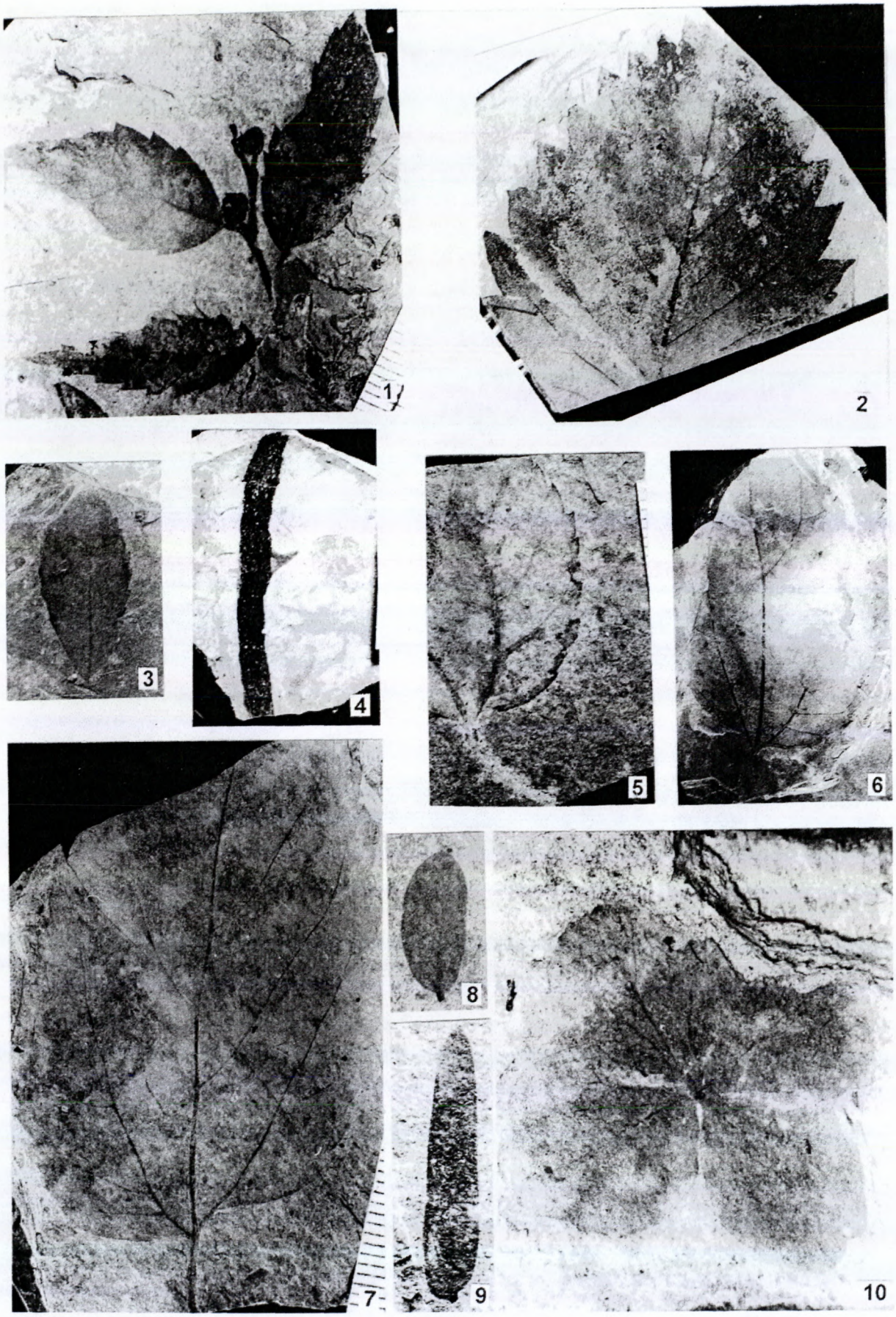


Plate 6

1 – *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba, 6 – PA 494, x 1.8,
2 – *Ulmus fischeri* Heer, PA 473, x 2,
3–4 – *Rosa lignitum* Heer, 3 – PA 459, x 1.5; 4 – twig, PA 1081, x 1.8,
5–7 – *Celtis* sp., 5 – PA 1080/1, x 1.5; 6 – PA 458, x 1.0; 7 – PA 468, x 2.0,
8 – *Leguminosites* sp., PA 446, x 3.0,
9 – *Mimosites haeringianus* Ettingshausen, PA 1075, x 3.5,
10 – *Hydrangea microcalyx* Sieber, flower, PA 447, x 4.

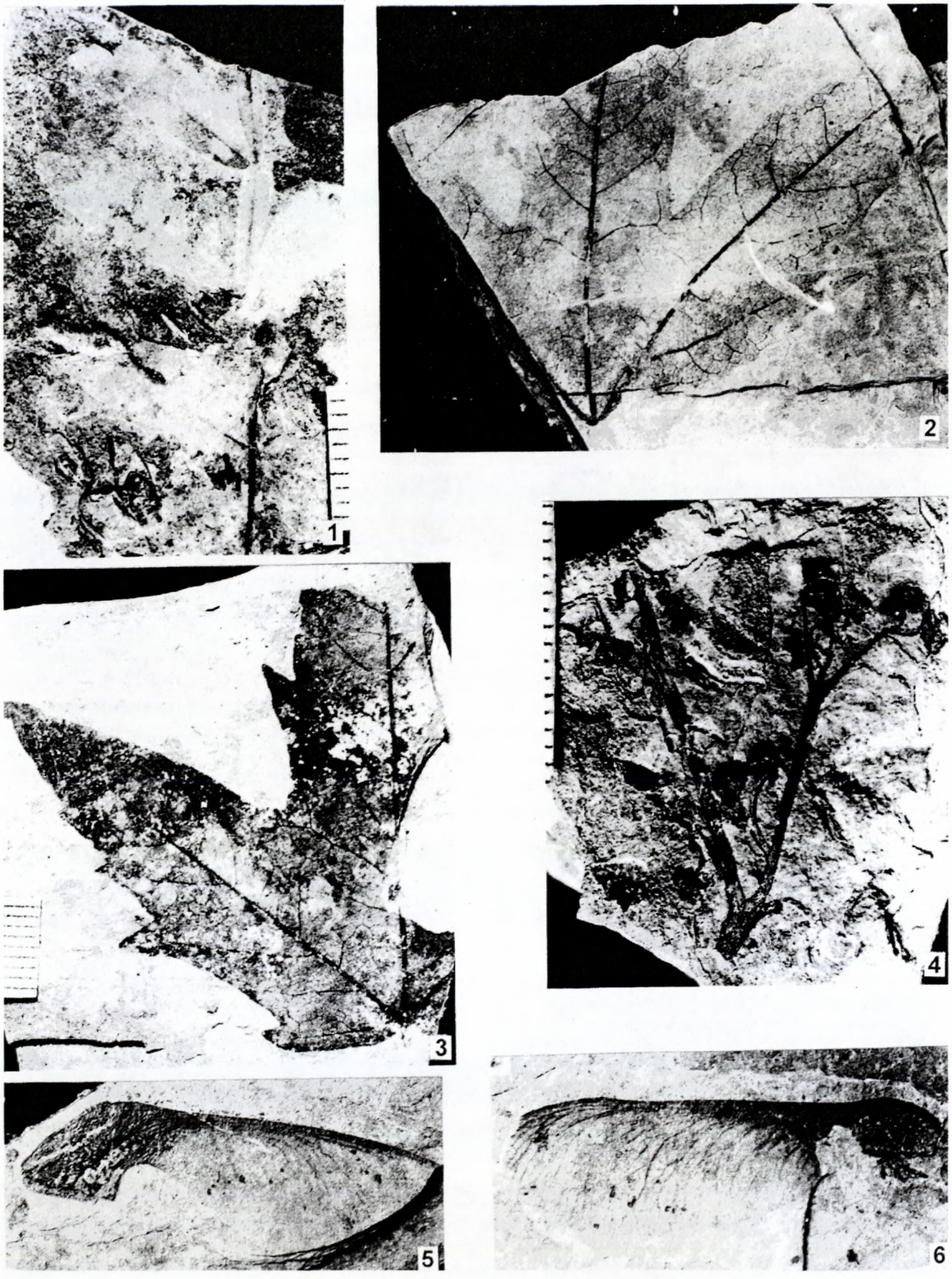


Plate 7

1 – cf. *Zanthoxylum* sp., PA 1067, x 2.5,
2–3 – *Acer* cf. *angustilobum* Heer, 2 – PA 498, x 1.6; 3 – PA 1073/2, x 1.8,
4 – *Carpolithes* sp., infructescence incertae sedis, PA 1077, x 3,
5–6 – *Acer* spp., fruits, 5 – PA 440, x 3; 6 – PA 450, x 3.

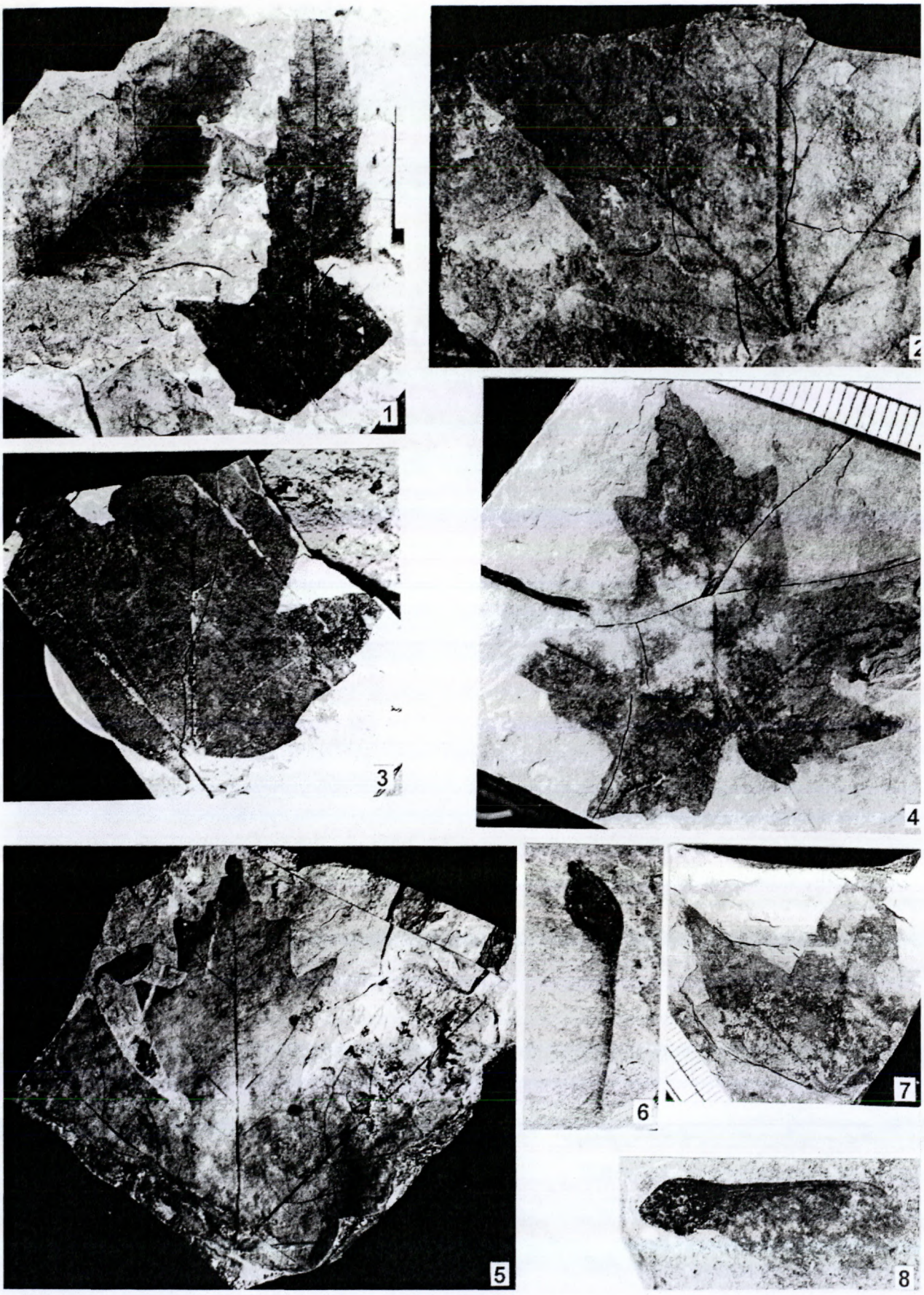


Plate 8

1 – *Acer* cf. *engelhardtii* Walther (right) and *Carpinus grandis* Goeppert (left), PA 1076a–b, x 1.1,

2–3 – *Acer* cf. *tricuspidatum* Bronn, 2 – PA 1098, x 1.9; 3 – PA 1095/1, x 1.6,

4–5 – *Acer palaeosaccharinum* Stur, 4 – private coll. Radoň, x 2; 5 – PA 1092/2, x 1.7,

6, 8 – *Acer* spp., fruits, 6 – PA 1101, x 3; 8 – PA 439, x 3,

7 – *Acer pseudomonspessulanum* Unger, PA 461, x 1.0.

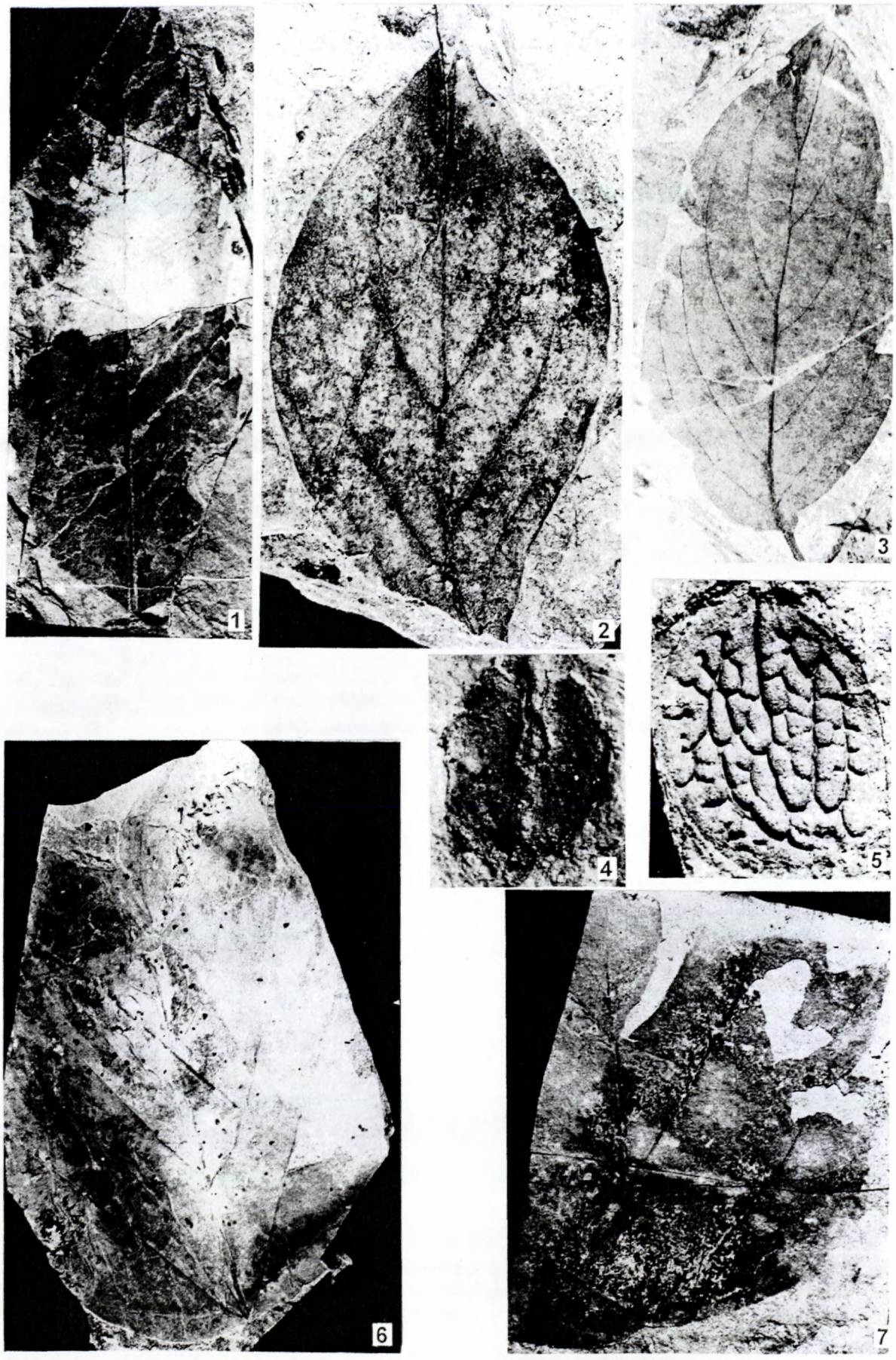


Plate 9

1 – cf. *Ailanthus prescheri* Walther, PA 1074/1, x 1.6,
2–3 – *Cornus studeri* Heer, 2 – PA 1099, x 2.5; 3 – PA 1115, x 2.0,
4 – *Ampelopsis* cf. *rotundata* Chandler, seed, PA 1029, x 10,
5 – *Palaeohosiea suleticensis* Z. Kvaček et Bůžek, fruit mold, PA 1069, x 2.6,
6–7 – *Ampelopsis hibschii* Bůžek, Z. Kvaček et Walther, 6 – PA 1089/2, x 1.1; 7 – PA 1104/1, x 1.6.

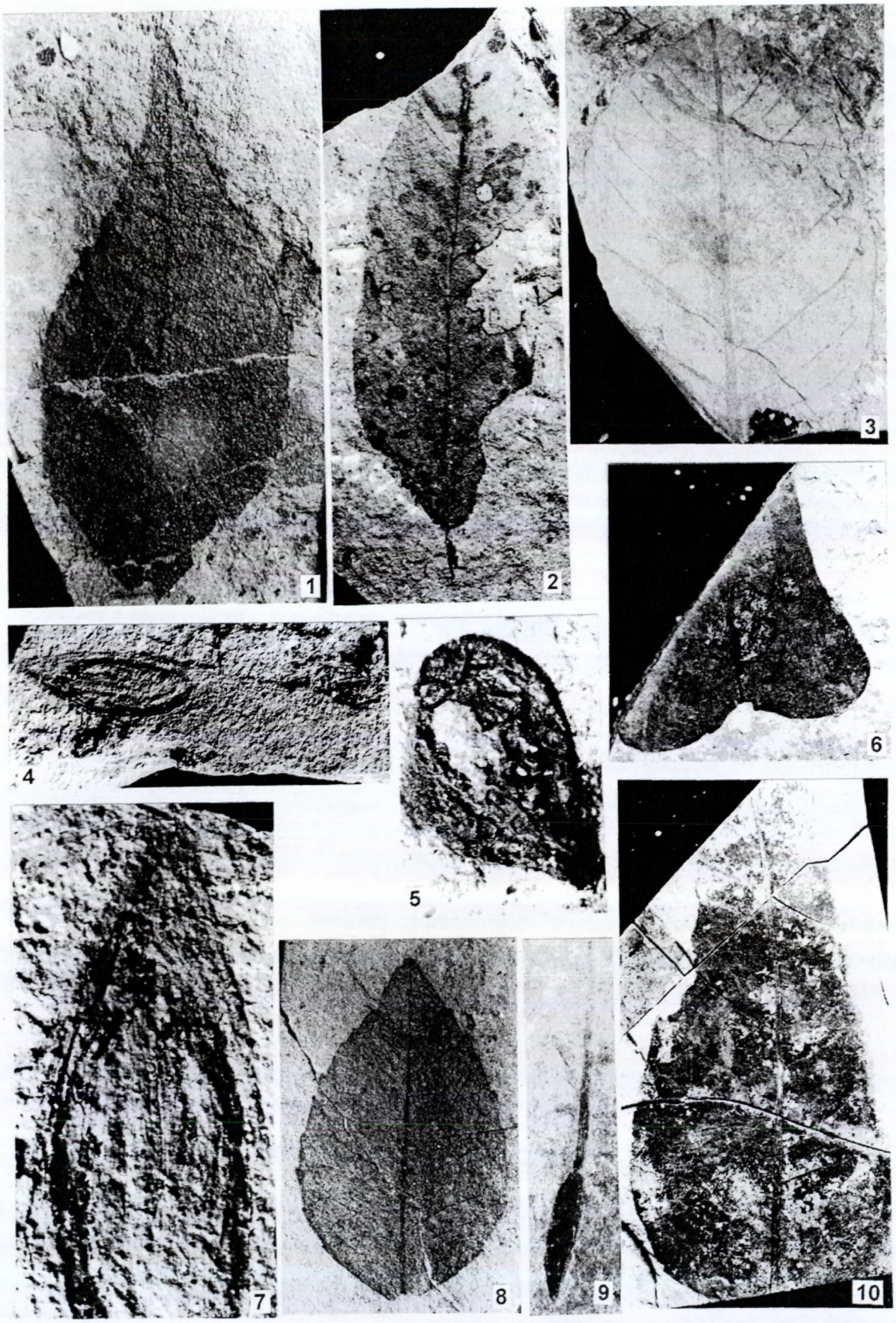


Plate 10

1 – "*Rhus*" *pteleaefolia* Weber, PA 466, x 2,
2 – *Dicotylophyllum heerii* (Engelhardt) Z. Kvaček et Walther, PA 1086, x 2,
3 – cf. "*Viburnum*" *atlanticum* Ettingshausen, PA 472, x 2,
4, 7 – "*Acer*" *sotzkianum* Unger, fruit, PA 1033, 4 – x 3; 7 – x 10,
5 – *Ampelopsis* cf. *rotundata* Chandler, seed, PA 1031, x 10,
6 – *Smilax weberi* Wessel, PA 1084, x 2,
8 – *Dicotylophyllum deichmuelleri* Z. Kvaček et Walther, PA 470, x 2,
9 – *Apocynospermum striatum* E.M. Reid et Chandler, seed, PA 448, x 4,
10 – *Oleinites maii* (Bůžek, Holý et Z. Kvaček) Sachse, PA 1088, x 1.5.

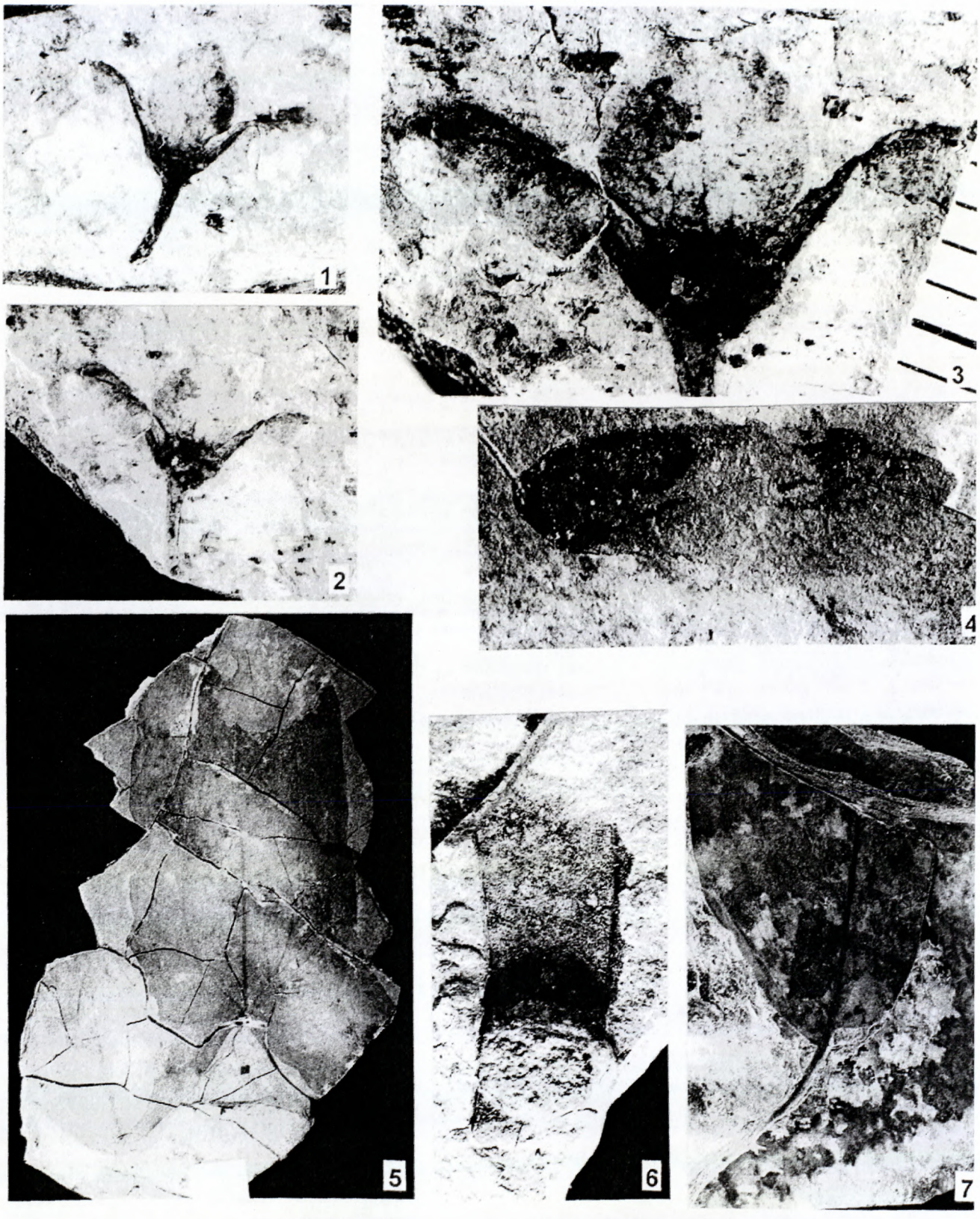


Plate 11

1–3 – *Antholithes* sp., flower, 1 – PA 1123/2, x 3; 2 – PA 1123/1, x 3; 3 – same specimen, x 7.5,

4 – *Saportaspermum* sp., seed, PA 1122/1, x 7.5,

5 – *Smilax weberi* Wessel (and *Leguminosites* sp. over the left basal lobe), PA 1119, x 1.0,

6 – *Leguminosites* sp., pod fragment, PA 1120, x 3,

7 – *Dicotylophyllum* sp. (cf. *Iodes*), PA 1124d, x 1.1.

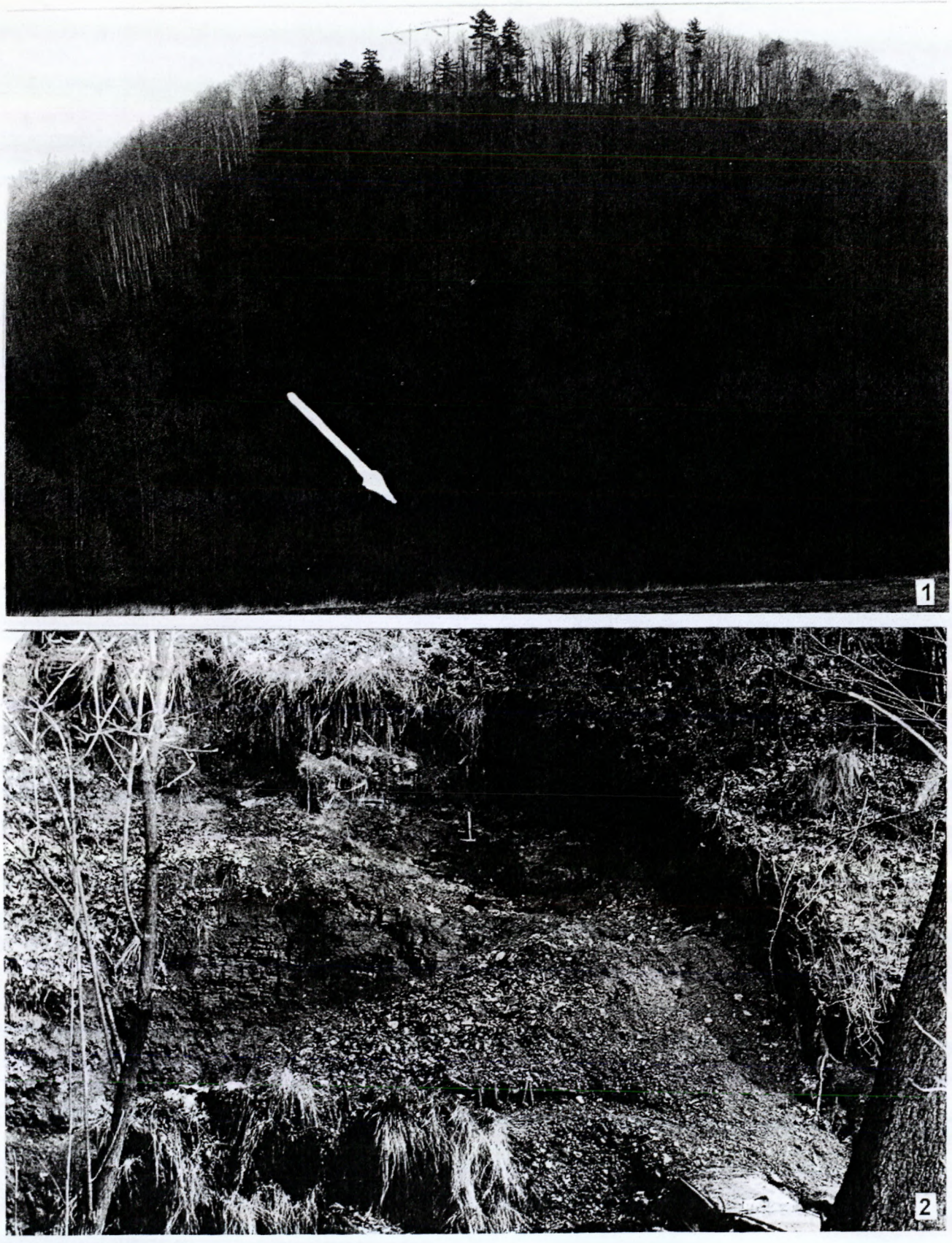


Plate 12
1 – Holý Kluk Hill, arrow – recovered locality,
2 – Detail of the outcrop.

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DENDROLOGICAL CHARACTERISTICS OF SUBRECENT FOSSIL PLANT REMAINS FROM THE UZON CALDERA IN KAMCHATKA (EASTERN RUSSIA)

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Abstract: The article presents fossilized plant remains from the Uzon caldera in Kamchatka for the first time. A problematic plant remain from diatomite, undetermined plant bulbs and several pieces of silicified herbs and wood as small stems and branches were recognized. Based on microscopic structure, one piece of stem was attributed to the genus *Salix* L. All presented fossils are silicified, connected to the former volcanic activity of the Uzon caldera.

INTRODUCTION

The Uzon Volcano forms a part of the Uzon-Geyzer volcano-tectonic depression positioned in central part of the Eastern Volcanic Belt of the Kamchatka Peninsula. The caldera of the Uzon Volcano represents a volcano-tectonic cauldron (9x12 km wide). The relatively flat caldera bottom lies 650 m above the sea level and raises up to 950 m above sea level at the eastern part of the caldera (Fig. 1). The altitude of the highest point of the crater rim is 1617 m above the sea level.

The Uzon Volcano belongs to active volcanoes, in spite of the fact that no historical eruption is known. Recently, the activity of the volcano is expressed by significant heat input from the depth and extensive solfatar activity on thermal fields. The hidden bottom of the caldera is made by basalts and covered by a layer of sediments that consists predominately of humid ash gravels with siltstones and clay beds. The specific structure of the caldera bottom, where the permeable layers are underlain by basalts with low infiltration capability, combined with high amount of rainfalls in this region and significant heat input, led to the formation of an extensive hydrothermal system that involves waters of different composition and temperature (Benning and Mountain 1996).

Heat input, presence of biologically active agents, extensive circulation and mixing of groundwaters and surface waters and a special caldera shape form in the Uzon Caldera a special microclimate, different from the other parts of Kamchatka. In the past, the areas of similar characteristics have been often centres of the death and fossilisation of different organisms. As such places are recently often used for palaeoecological interpretations, it is very important to study recent analogous areas in order to predict the influence of the volcanic and hydrothermal activity on flora and fauna composition.

GEOLOGICAL EVOLUTION OF THE UZON VOLCANO

The following description of geological evolution of Uzon is based on the studies done by Brayceva *et al.* (1968), Averyev *et al.* (1971), Brayceva *et al.* (1974), Karpov (1989), Leonov *et al.* (1991), Neshetaeva *et al.* (1994), Grib (1998), Vergasova *et al.* (1998), Zolotarev *et al.* (1998). The Uzon Volcano started to form during Pleistocene (370 000–750 000 ybf). At that time, a huge shield volcano arose at the region of the recent volcano-tectonic depression. Volcanic products of this volcano represented by olivine-pyroxene and pyroxen-plagioclase basalts are exposed at the western part of the caldera. During Middle and Late Pleistocene number of eruptions destroyed the shield volcano and the caldera has been formed. 225 000–270 000 ybf ago a stratovolcano formed at the western part of the caldera. Basicity of products of the stratovolcano (two-pyroxene basalts with olivine) was lower when compared to the original shield volcano. During upper Late Pleistocene (175 000–225 000 ybf) a cummulative crater producing acid lavas existed at the eastern part. Huge layers of vitric ignimbrites of different colours and structures formed to the south and north of the caldera. Pemza layer (situated recently in the eastern part of caldera) formed in the crater.

Volcanic activity continued in Late Pleistocene (70 000–100 000 ybf) at the western part of the complex. At that time Uzon-Geyzer volcano-tectonic depression and the Uzon cauldron received the recent shape. After decreasing of volcano-effusive activity the caldera bottom was covered by large lakes. Sedimentary fill of the caldera started to form that time (Melekseev *et al.* 1974, p. 181). Lake basins existed in the caldera 40 000–70 000 ybf ago. The caldera recent shape was influenced by great ignimbrite explosions in the western part of the caldera. Buried soils below ignimbrites near the Kronocké Lake were dated to

36 600±1000 ybf (Egorova 1993). Palynological analysis in the layers below ignimbrites at the Bezymjannaja and Unana rivers provided Upper Pleistocene age, corresponding to the Kazancev interglacial age (Egorova 1993).

10 000–30 000 years ago the region was tectonically reactivated and at the east-south-east part of the caldera the dacite cone of the Gora Belaja Hill formed. Acid volcanism of the Gora Belaja Hill was accompanied by the pemza extrusion and the agglomerate flows. In that time also andesite-basalt pyroclastic material was extruded and in result the maar lake Dalnoje formed. Besides the volcanic activity, the lacustrine-fluvial sedimentation continued and recent hydrothermal system has been established. Kraeva *et al.* (1979) described 3 phases of the lake evolution. Tuff layers, sandstones and gravels gradually sedimented in the lakes. The material came from the surrounding cones and caldera walls. During Holocene sedimentary filling changed with climate. Sedimentation of diatoms at the early stages was followed by the clastic sedimentation. Lacustrine-swampy types of sedimentation were also often present. A unique undetermined plant remain (Pl. 1, fig. 1) was found at the Mt. Belaya.

PALAEOBOTANIC AND BOTANIC ENVIRONMENT

Palynological analyses, like analysis of diatoms (Egorova 1993), show floristic changes beginning at the end of the late Pleistocene. Bush and tree pollen associations (*Betula costatae*, *Alnaster* and rarely *Pinus pumila*) prevail (46%) in the basal sediments. Other pollen components are presented by herbs (16%, mostly with Compositae), ferns, *Lycopodium* and moss spores. *Abies* is missing at all. Diatoms represent a slightly temperate assemblage with 98% of eurytherm species and only 1% being supposed to be a south boreal species. The arctic and arcto-boreal species are absent. More temperate assemblage was recorded in the left affluent of the Shumnaya River – south boreal species form 6% of the total diatom assemblage. The diatoms proved the Pleistocene climatic optimum.

Younger sediments, developed around the Khloridnoe and the Fumarolnoe Lakes (places of finds of fossilized wood), contain a peat assemblage typical of colder conditions. Herbs (Cyperaceae, Gramineae, *Artemisia*) prevail in the pollen spectrum (more than 50% of total species number), spores are represented by 32% (with 96% of moss species), trees are completely missing and bush plants form 17% only. This is an assemblage typical of glacial climate. The existence of lakes in the ice vicinity is supposed – wet conditions could be assumed by the presence of *Salix*.

The last glacial climatic phase has been at climax 13 000 –11 000 years before present. Palynological analysis of the buried soil just below the Mt. Belaya shows poor living conditions during the last glacial phase (which could be in relation with the Norilsk phase of northern Siberia and/or with the late Dryas in Europe). The climate is supposed to be dry and cold. Bushes (30%) are represented by *Alnaster* (80%) and *Betula nana* (20%). At the beginning of Holocene, the lake water level decreases and the erosion is apparent. Contemporaneous lakes at the Uzon Caldera are the only relicts of the last glacial phase. Egorova (1993) divided Holocene plant assemblages into five complexes:

I. 10,300–9,200 years before present (ybp) – grass and bush
II. 9,200–6,000 ybp – bush with dominant *Alnaster*, *Betula* forest
III. 6,500–4,500 ybp – *Betula* forest prevails
IV. 4,500–2,500 ybp – bush, *Alnaster*, *Pinus pumila*, *Betula*
V. 2,500– 0 ybp – new phase of *Betula* forest.

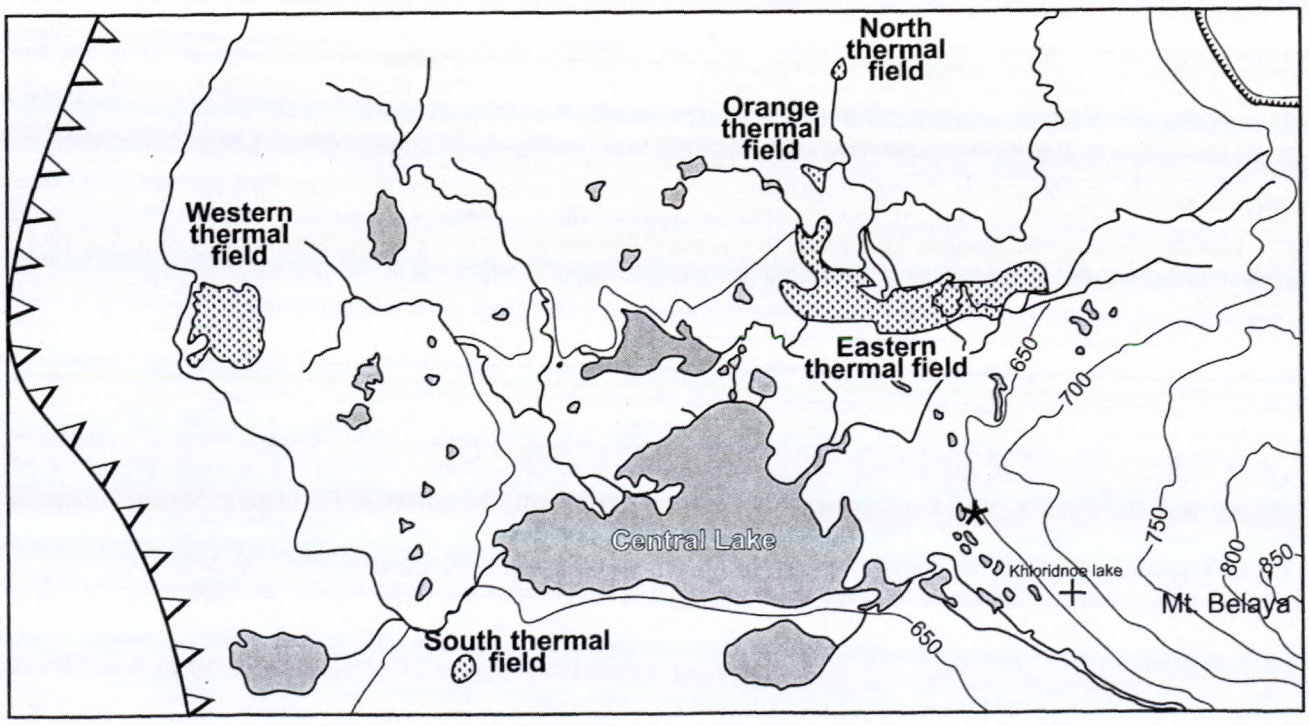


Fig. 1. Schematic sketch of western part of Uzon Caldera in Kamchatka (after Karpov 1989).
★ - mineralized bulbs, + - fossilized wood.

Two/three thousand years before present, the explosion at the Khloridnoe Lake buried a soil horizon (Karpov pers. comm.). However, the radiometric dating shows a large divergence (several thousand years). It is clear that the diagenetic processes and temperature rise changed these data. Palynological analysis of sediments containing fossilised woods and bulbs (see Pl. 1, figs. 4 and 5) show a rise of bush plants (50%–38% *Alnaster*, *Pinus pumila* 20%, *Betula* 36%) and grass 22% (Gramineae, Ericaceae, Cyperaceae). This is a typical assemblage of the IVth complex sensu Egorova (1993).

DENDROLOGICAL CHARACTERISTICS

Our dendrological study deals with a single relatively well preserved piece of fossilized wood.

The piece of wood (No. IGP-Ka. 2000/1) is silicified, 40 mm wide, 70 mm long and light beige in colour. Microscopically, the wood shows a diffuse to semi-ring porous pattern with growth rings 1–3.5 mm wide (Pl. 1, fig. 7). The vessels are round to oval in cross-section, mainly solitary, but also in radial multiples of 2, 3, or rarely of 4. The early wood pores are about 55 μm in tangential diameter, the late wood pores are 20–30 μm in tangential diameter. The vessel elements are limited by simple perforation plates, the intervascular pits are bordered, hexagonal, alternate, quite dense, 7–10 μm in diameter (Pl. 1, fig. 8). The fibres are libriform, polygonal in cross-section, tracheids are missing. The axial parenchyma is apotracheal diffuse. The rays are heterogeneous (Pl. 1, fig. 9), uniseriate (Pl. 1, fig. 8), up to 14 cells (240 μm) high. They are about 20 in number per transversal horizontal mm. The ray cell dimensions (tangential height × tangential width × radial length) are: 8–23 μm × 8–20 μm × 35–75 μm.

The features discussed above, especially diffuse to semi-ring porous wood pattern, simple perforation plates and uniseriate heterogeneous rays, are typical of the genus *Salix* L. (e.g., Schweingrüber 1978). In spite of the fact that this genus is quite reliable, the attribution to a concrete species remains problematic. Therefore, we prefer to leave our determination at the generic level only.

CONCLUSIONS

We presented several fossilized plant remains from the Uzon Caldera of Kamchatka: a problematic plant remain from diatomite (in this area, for the first time in such a type of rock), plant bulbs and silicified herbaceous and wood pieces as small stems and branches. One piece of silicified wood stem was identified as a willow (*Salix* L.).

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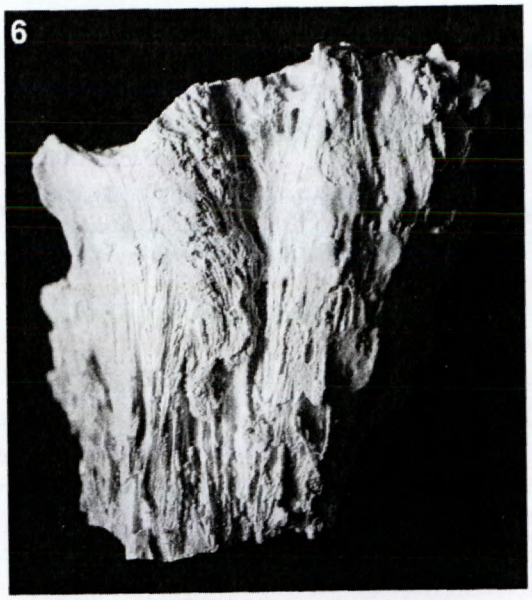
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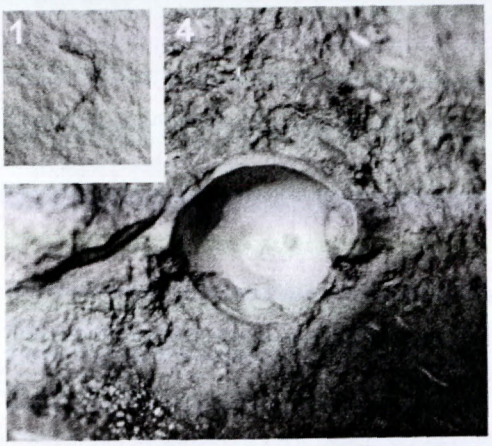
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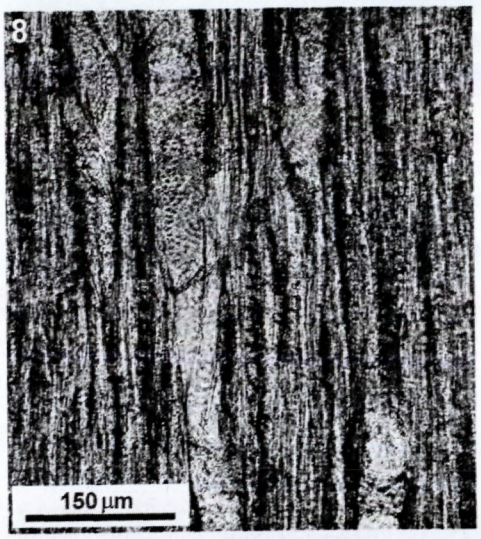
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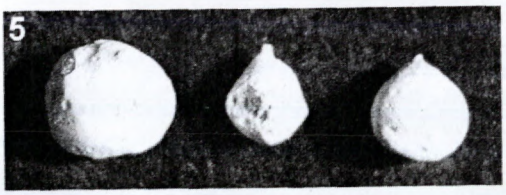


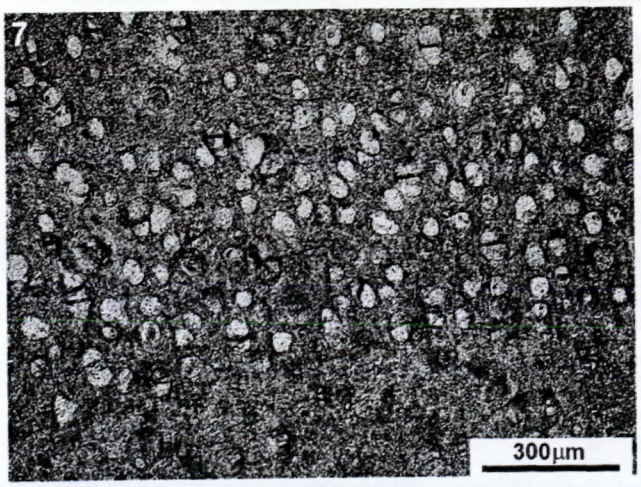












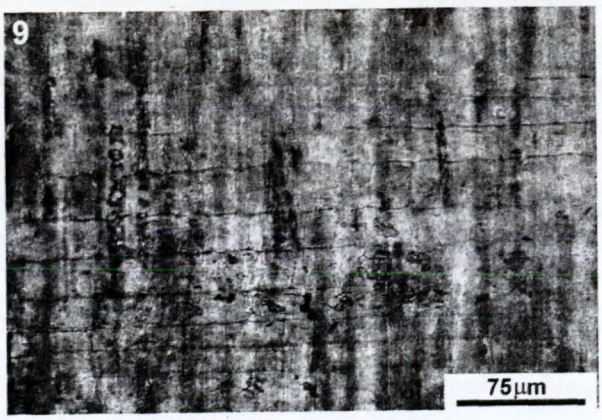


Plate 1

1. undetermined plant remain in diatomite, 7 mm height (No. IGP-Ka. 2000/2),
2. silicified branch, 70 mm height, 7 mm width (No. IGP-Ka. 2000/3),
3. herbaceous stem, piece of rock 150 mm length, 70 mm height (No. IGP-Ka. 2000/4),
4. cast of a silicified bulb, 20 mm length, 15 mm width (No. IGP-Ka. 2000/5),
5. three isolated bulbs, 10–13 mm height, 10–15 mm width (Nos IGP-Ka. 2000/6-8),
6. small piece of wood stem 50 mm height, 50 mm width (IGP-Ka. 2000/9),
7. wood of *Salix* L. (No. IGP-Ka. 2000/1) – transversal section: transition between latewood and earlywood vessels,
8. same – tangential section: note intervascular pits, simple perforation plates and uniseriate rays,
9. same – radial section: heterogeneous uniseriate rays with upright cells in the middle and procumbent cells in the lower part.

All specimens are deposited in the Palaeontological collections of Institute of Geology and Palaeontology, Charles University, Prague.

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REMARKS ON TURONIAN MICROBIOSTRATIGRAPHY IN THE TETHYAN AND BOREAL REALMS

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Abstract: Some species of genera in the Superfamily Globotruncanacea Brotzen, 1942 are biostratigraphically important in the Turonian of the Tethyan (Tunisian Atlas, Western Carpathians of Slovakia) and Boreal (Bohemian Cretaceous Basin) realms. The microbiostratigraphical difference is manifested in the Early Turonian of the Western Carpathians by the absence of the genus *Whiteinella* Pessagno. Further on the difference is in the upper part of the Helvetoglobotruncana helvetica Zone, in which the species *Caronita turona* (Olbertz), present in the Bohemian Cretaceous Basin and Western Carpathians, is missing in other parts of the Tethyan Realm. On the contrary, the species *Caronita kalaati* (Gonzales Donoso and Linares, 1990) and *Caronita pileoliformis* (Lamolda, 1977) are present. The Late Turonian of the Tethyan Realm is extraordinarily rich in planktic and benthic foraminifers which are also characterized by a considerable variability. In the Late Turonian of the Western Carpathians, microfauna was impoverished, still more distinctly than in the Boreal Cretaceous Basin of the Bohemian Massif. However, benthic microfauna is very diverse and variable as to genera and species. Three new species are described: *Concavatotruncana praeconcavata* n. sp., *Caronita mellegiana* n. sp. and *Falsomarginotruncana barri* n. sp.

INTRODUCTION

Early Turonian. For stratigraphy of the Early Turonian the genera *Whiteinella* Pessagno, 1967 and *Dicarinella* Porthault, 1970 are the most important.

Whiteinella gigantea (Lehmann) is an index fossil for the zone of the "grandes globigerines" (Lehmann 1963). It was described as ?*Praeglobotruncana gigantea* Lehmann, 1963. This species was used by Bolli (1966) for the definition of his new Praeglobotruncana gigantea Zone. However, Porthault (1969) considered it conditionally as homonym (but not synonym) of formerly described *Praeglobotruncana biconvexa gigantea* Samuel and Salaj (1962). This is why he introduced a new taxon *Whiteinella lehmanni* Porthault, 1969. Regarding it, van Hinte (1976) established the Whiteinella lehmanni Zone (1974).

It should be considered that *Praeglobotruncana biconvexa gigantea* Samuel and Salaj, 1962 belongs to the genus *Dicarinella* Porthault, 1970 (in Donze *et al.* 1970). Thus, we cannot consider both *Whiteinella gigantea* (Lehmann) and *Dicarinella biconvexa gigantea* (Samuel and Salaj) as primary, but as secondary homonyms. Salaj and Gašpariková (1983, p. 593) stressed the validity of the name *Whiteinella gigantea* (Lehmann) in the sense of the International Code of Zoological Nomenclature, too (Gonzáles Donoso and Linares in Robaszynski *et al.* 1990, p. 318).

On the other hand, Robaszynski and Caron (1979) although correctly attributing *Whiteinella lehmanni* Porthault in the synonymy of *Whiteinella gigantea* (Lehmann), included both these species with the synonymy *Whiteinella archaeocretacea* Pessagno, 1967. If all these taxa are identical, *Whiteinella archaeocretacea* Pessagno, 1967 must be synonym of *Whiteinella gigantea* (Lehmann, 1963). However, distinct morphological differences and different stratigraphic ranges exclude the discussion about their possible synonymy: *Whiteinella archaeocretacea* Pessagno as species described by Pessagno (1967) from the tops of the Helvetoglobotruncana helvetica Zone does not occur in the Upper Cenomanian to Lower Turonian strata and it has never been found in the lower and middle parts of the Helvetoglobotruncana helvetica Zone.

Whiteinella archaeocretacea (Pessagno) appears at the top of the Helvetoglobotruncana helvetica Zone together with the forms morphologically very similar to *Whiteinella inornata* (Bolli). *Whiteinella archaeocretacea* may be possibly regarded as a subspecies of *Whiteinella inornata* (Bolli) in Salaj, 1997. Therefore, it is necessary that all the so called "literary" occurrences of the species *Whiteinella archaeocretacea* Pessagno in the Whiteinella gigantea Zone undergo a future revision.

Sigal (1987) does not recommend to use the name *Whiteinella archaeocretacea* for this zone and suggests to rename it to the zone "Paradubia – aprica" as proposed by Lorigo and Mantovani (1970, cf. Sigal 1987). The name for this zone originated by combination of the names for the zone Paradubia used by Lorigo and Mantovani (1970) (cf. Sigal 1987) and of the name for the zone aprica proposed by Wonders (1971) (in Sigal 1987, p. 35). Sigal (1987, p. 35) notes that the zone Paradubia aprica may correspond to the zone of Douglas (1969) termed as *Praeglobotruncana roddai* (= syn. *Dicarinella hagni* (Scheibnerová)).

It is worth to mention that the species *Whiteinella hoelzlii* was described by Hagn and Zeil in 1954, later also *Whiteinella aprica* (Loeblich and Tappan) by its authors in 1961 from the Cenomanian/Turonian boundary interval. The last species was used by Bellier (1983, p. 156) as index fossil of his new Whiteinella aprica Zone. This author considers

MICROBIOSTRATIGRAPHICAL DIVISION AND ZONATION OF THE MESOGEAN TURONIAN HYPOSTRATOTYPE (TUNISIA) ON THE BASIS OF PLANKTONIC FORAMINIFERS

(After J. SALAJ 1976, 1980, 1997, modified)

Tab. 1

Whiteinella gigantea (Lehmann) as a synonym of *Whiteinella aprica* (Loeblich and Tappan).

Having at disposal several topotype specimens for revision of the species *Whiteinella aprica* (Loeblich and Tappan) from Loeblich and Tappan, we distinguish the following differing marks: The species has a larger and deeper umbilicus than *Whiteinella gigantea.* Moreover, the chambers in the studied species are more lobate and more elongated so that individual chambers of the last whorl are more and deeper separated by sutural free spaces from one another. On the contrary to *Whiteinella aprica,* the chambers of the species *Whiteinella gigantea* are less lobate and more tightly ordered. Without any doubt these species are phylogenetically very close, but the younger species *Whiteinella aprica* (Loeblich and Tappan) appears later in the Whiteinella gigantea Zone, probably in the Turonian part of this zone only. An independent taxonomic position of the species *Whiteinella gigantea* (Lehmann) and of *Whiteinella aprica* (Loeblich and Tappan) is also accepted by Robaszynski *et al.* (1990).

The earlier opinion of Loeblich and Tappan (1988) and Salaj (1997) that *Whiteinella aprica* (Loeblich and Tappan) could be a synonym of the species *Whiteinella hoelzli* (Hagn and Zeil) (= *Hedbergella hoelzli* in Robaszynski, Caron and E.W.G.P.F. 1979) can probably be accepted. We noted that *Whiteinella hoelzli* has a very rugose surface of the test, which is less convex and has a lower profile at the test periphery than *Whiteinella gigantea* (Lehmann).

It is necessary to mention that Salaj (1970) considered *Whiteinella gigantea* (Lehmann) as a synonym of *Rotundina* (=*Archaeoglobigerina*) *cretacea* (d'Orbigny). For this reason, the name of the Early Turonian Rotundina cretacea – Praeglobotruncana imbricata Zone of Salaj (1980) was incorrect. The species *Whiteinella gigantea* (Lehmann) is however, a form ancestral in development of the species ?*Archaeoglobigerina cretacea* (d'Orbigny).

Due to the primary absence of *Whiteinella gigantea* (Lehmann) in several paleontologically specific parts of the Tethyan Realm, Salaj and Samuel (1966, 1984) introduced a new Turonian Dicarinella imbricata Zone with Dicarinella imbricata and Dicarinella hagni Subzones in the Western Carpathians, as applied also by Maamouri *et al.* (1994) in Tunisia in the frame of the Whiteinella gigantea Zone.

Characteristic taxa were identified in the Lower Turonian (Bílá Hora Formation) of the northern part of the Bohemian Cretaceous Basin. On the base of the Lower Turonian the assemblages of planktic foraminifers consist mostly of hedbergellids. In the overlying layers the assemblages are characterized by the whiteinellids, such as *W. gigantea* (Lehmann) (= *W. archeocretacea* Pessagno) and *Dicarinella imbricata* (Mornod). In the upper part of the Lower Turonian *Dicarinella hagni* (Scheibnerová) is found (Štemproková-Jírová 1992).

The Whiteinella gigantea Zone with whiteinellas is also missing primarily at the NE Caucasus (Tur 1960). Thus similarly as in the Western Carpathians, also in the NE Caucasus, overlying the Rotalipora cushmani Zone, there is a carbonate facies which obviously corresponds in age to the Dicarinella imbricata Zone, and which is not proved in the NE Caucasus. As it is, however, visible from the plotted profile (Tur 1996, p. 261, Fig. 2,), a hiatus is not present here. In samples no 21 and 22 of the studied section, formed by limestones and marls, representatives of the species *Dicarinella imbricata* (Mornod) could be found at least scarcely, similarly as they are found in this zone in Dagestan (Orel 1970, in Tur 1996). Overlying this formation "free of fossils", the foraminifers association of the Dicarinella hagni Zone is present, similarly as in the Western Carpathians. Dicarinella hagni. Zone corresponds to the higher part of the Early Turonian, but with the presence of the genus *Whiteinella.*

Upper part of the Lower Turonian to the Middle Turonian. The genera *Helvetoglobotruncana* Reiss, 1957 and *Dicarinella* Porthault, 1970 are important for the Middle Turonian stratigrahy. *Helvetoglobotruncana helvetica* (Bolli) consisting of two morphological groups is an index species of a homonymous Turonian zone. The first group is represented by small forms of the 1st–2nd depth zones in the Boreal areas of Europe. The latter group consists of large forms of the 3–4th depth zone, appearing at the base of the upper part of the Lower Turonian (for example in the Tunisian El Kef section).

Helvetoglobotruncana helvetica (Bolli) is always missing in shallow neritic platform conditions (for example Central Tunisia). Sporadic occurrences of this species cannot serve as a criterion of time range within the mentioned zone (Salaj, 1987). *H. helvetica* (Bolli) is found very rarely in sediments of the Bohemian Cretaceous Basin (BCB) (Štemproková- Jírová 1992).

In lower and middle part of the Helvetoglobotruncana helvetica Zone in the Mediterranean Region (Tunisia) as well as in the Boreal region (Bohemian Massif) an equal type of benthonic as well as of planktonic microfauna occurs.

Representatives of the genus *Whiteinella* Pessagno, 1967 are abundant in the Boreal as well as Tethyan realm, besides the Western Carpathians. The reason for this, as mentioned by Salaj and Gašpariková (1979), were unfavourable paleoecological conditions in this particular isolated Northern Tethyan branch, caused by the proximity of coast and higher temperature of surface waters.

a) The lower part of the Helvetoglobotruncana helvetica Zone is represented by planktonic foraminifers of the Dicarinella trigona Subzone, defined by Salaj and Samuel (1966). Besides the index species, *Dicarinella oraviensis* (Scheibnerová) and *Dicarinella hagni* (Scheibnerová) characteristic species are present. The last named species was determined first by Salaj and Samuel (1966, p. 267) as *Globotruncana coldreriensis* Gandolfi. Of benthic species the most significant is the presence of *Globorotalites hangensis* (Vassilenko). The lower part of the Helvetoglobotruncana helvetica Zone was defined by Pessagno (1969) and Douglas (1969) as the Globotruncana sigali Subzone. Its index species *Caronita sigali* (Reichel) is found only in the uppermost part of the Middle Turonian to the lowermost part of the Late Turonian (Salaj and Samuel 1966, p. 267).

b) The middle part of the Helvetoglobotruncana helvetica Zone is characterized by the Dicarinella biconvexa Subzone, originally defined by Salaj and Samuel (1966).

The Dicarinella biconvexa Subzone is mainly typical by representatives of the genus *Dicarinella.* It has a large

spectrum of relatively considerably variable and related species. As to the age, *Dicarinella imbricata* (Mornod) is the oldest one, appearing at the base of the Turonian. Higher up, in the upper part of the Early Turonian, *Dicarinella hagni* (Scheibnerová, described in December 1962) and *Dicarinella turonica* (Samuel and Salaj, 1962) appear, the latter being an ancestral form of the species *Dicarinella trigona* (Scheibnerová) (Salaj and Gašpariková 1983). The species are also abundant in the lower and middle parts of the Helvetoglobotruncana helvetica Zone. Further significant species, besides *Dicarinella oraviensis* (Scheibnerová) and *Dicarinella trigona* (Scheibnerová), passing from the lower part of the Helvetoglobotruncana helvetica Zone, are represented mainly by the species which appear as the first *Dicarinella biconvexa* (Samuel et Salaj, described in August 1962), *Dicarinella gigantea* (Samuel et Salaj) and *Dicarinella elata* (Lamolda, 1977). In the northern part of the Bohemian Cretaceous Basin the lower part of the Helvetoglobotruncana helvetica Zone is characterized by the occurrence of *Dicarinella hagni* (Scheibnerová) and *Dicarinella elata* Lamolda (= *D.* aff. *hagni*), the middle part of this Zone is characterized by *Falsomarginotruncana* ex. gr. *schneegansi* (= *Marginotruncana*) (Štemproková-Jírová 1992).

The species *Dicarinella biconvexa* is an ancestral form of the species *Dicarinella fusani* Salaj et Samuel (1977), which in development is the predecessor of the genus and species *Caronita sigali* (Reichel). *Dicarinella elata* (Lamolda) is an ancestral form in the development of the species *Dicarinella carpathica* (Scheibnerová). These species are important for stratigraphy of the Tethyan Middle Turonian. Their significance, for instance, in the Roumanian Carpathians was stressed by Ion (1983). She emphasized their independance as valid taxons and differed them from the species *Dicarinella difformis* (Gandolfi), *Dicarinella indica* (Jacob et Sastri) and *Dicarinella algeriana* (Caron, 1966). On the contrary, Lamolda (1977) considered the species *Dicarinella turonica* (Samuel et Salaj) as a synonym of *Dicarinella difformis* (Gandolfi). He also discussed that the synonymy of this species also included *Dicarinella biconvexa* (Samuel et Salaj) and the species *Dicarinella gigantea* (Samuel et Salaj, 1962) and/or this latter species belongs to the synonymy of the species *Dicarinella algeriana* (Caron). In contrast to the concept of Lamolda (1977) González Donoso et Linares in Robaszynski *et al.* (1990) have different opinion. They include also *Dicarinella oraviensis oraviensis* (Scheibnerová) into the synonymy of the species *Dicarinella hagni* (Scheibnerová) (Pl. 37, figs. 4 a, b, c, Pl. 38, figs. 2 a, b, c) and the species *Dicarinella carpathica* (Scheibnerová), figured by Samuel et Salaj (1966, Pl. 37, figs. 2 a, b, c, figs. 3 a, b, c and figs. 6 a, b, c) they either consider as the species *Praeglobotruncana stephani* (Gandolfi) (Pl. 37, figs. 2 a, b, c) or as a type transitional between *Praeglobotruncana stephani* (Gandolfi) and *Sigalitruncana* sp. cf. *Dicarinella hagni* (Scheibnerová) (Pl. 37, figs. 3 a, b, c) or as *Dicarinella hagni* (figs. 5 a, b, c and 6 a, b, c).

The most important subzone of the Helvetoglobotruncana helvetica Zone for considering the onset of paleogeographical differences between the Tethyan and Boreal realms is the Caronita sigali Subzone, defined as the Globotruncana sigali Subzone by Pessagno (1969) and Douglas (1969). This subzone was renamed by Salaj (1975) to the Globotruncana turona Subzone, in taxonomic sense as *Caronita turona*. The reason for this was that there is the oldest described taxon by Olbertz (1942) from the Boreal biogeoprovince and moreover, that the species *Caronita sigali* (Reichel) as a subspecies *Caronita turona sigali* (Reichel) was described by Salaj (1975).

The species *Caronita turona* (Olbertz) is found in the Boreal Turonian of the Bohemian and German regions only and occurs, however relatively scarcely, in the Western Carpathians Tethyan Region. Here it represents a relatively isolated northern branch (Salaj et Gašpariková, 1979) with the species *Falsomarginotruncana coronata* (Bolli), *Falsomarginotruncana schneegansi* (Sigal) emend. (Caron) and *Marginotruncana marginata* (Reuss) emend. Jírová, 1956 found in the uppermost part of the Caronita turona Subzone. We note the presence of the two-keeled forms of the species "*Globotruncana*" *sigali* Reichel, as described and figured from Libya by Barr (1972, p. 23, Pl. 7, figs. 1a,b,c).

The Caronita turona Subzone should be accepted for the Boreal Region only in case that the species *Caronita sigali* (Reichel) is not found. This species is, however, abundant in the Western Carpathians region. We propose for this region, with regard to the fact that Tethyan as well Boreal species occur here, the name of the subzone Caronita sigali – Caronita turona Subzone. The species *Caronita turona* is mainly represented in the BCB in the lower part of the Teplice Formation (Late Turonian).

For clarifying the problem of the uppermost part of the Helvetoglobotruncana helvetica Zone, it could be noted that *Praeglobotruncana hilalensis* Barr, 1972, is a form described by Barr (1972, p. 15, Fig. 4 a, b, c) from the Coniacian. This species has two pustulose keels on the five chambers in the last whorl and only one keel on the last chamber. Therefore, the species *Praeglobotruncana hilalensis* Barr, which is mentioned by Robaszynski *et al.* (1990, Pl. 33, figs. 3 a, b, c) from the Middle Turonian, corresponds to the species *Caronita sigali* (Reichel). Other specimen, figured in Pl. 33, figs. 4–5 a, b, c, is very close in morphology to the species *Caronita turona* (Olbertz) sensu Salaj (1980), but identical with the holotype of the species *Caronita kalaati* (González Donoso et Linares) in Robaszynski *et al.* (1990, p. 327, Pl. 30, figs. 5 a, b, c) also with paratype of this species (Pl. 30, figs. 6 a, b, c).

We remark that the further specimen of the species *Caronita kalaati* (González Donoso et Linarez) figured in the work by Robaszynski *et al.* (1990, Pl. 31, figs. 1 a, b, c – 2 a, b, c) is a synonym of the species *Caronita neoschneegansi* (Salaj, 1987), which is mainly found in the Late Turonian. Morphologically larger forms are also found in the Coniacian (area of the El Fahs and El Kef, Tunisia). Besides that, the species described by González Donoso et Linares (in Robaszynski *et al.* 1990, Pl. 33, figs. 1 a, b, c) as *Praeglobotruncana* sp. cf. *Praeglobotruncana kalaati* n. sp. coresponds to the species *Caronita sigali* (Reichel).

As to the relation of the Helvetoglobotruncana helvetica T.R. Zone within the Turonian, its lower boundary begins in the upper part of the Mammites nodosoides Zone (Robaszynski *et al.* 1990, Maamouri *et al.* 1994). On the

contrary, the upper boundary of the Helvetoglobotruncana helvetica Zone in Tunisia (Kalaat Senan), according to Robaszynski *et al.* (1990), reaches at the base of the upper part of the interval zone Coilopoceras. We explain the absence of the index *Helvetoglobotruncana helvetica* (Bolli) in the upper part of the Coilopoceras Interval Zone by a distinct character of sedimentation in a shallow-water environment. The occurrence of the species *Helvetoglobotruncana helvetica* (Bolli) in this time section is related to a deeper sedimentation environment. The shallow water character of the environment in the area of Kalaat Senan in the Turonian is confirmed by the abundance of Ophiuroidea fragments, which were proved by one of us in this area (J.S.). This material is object of a detailed study by R. Štorc now. As to the upper boundary of the Helvetoglobotruncana helvetica T.R.Z., we share the view of Sigal (1987) that the upper boundary of the Helvetoglobotruncana helvetica T.R.Z. is determined by the base of the Late Turonian ammonite Zone Romaniceras deverianum. This is in accordance with earlier views of Sigal (1955), Bolli (1966), Salaj and Samuel (1966), Salaj (1969, 1970), Robaszynski and Caron (1979, 1986, 1996), Wonders (1980) and Caron (1985).

In Tunisia in the area of El Fahs (Jabal Fguira Salah) in the uppermost part of the formation of the Helvetoglobotruncana helvetica T.R.Z. is represented by a 1.5 m thick layer of micritic limestone rich in inocerams (*Mytiloides* ex gr. *fiegei* a.o., see Salaj 1996). A rich nannoplankton with abundant species *Marthasterites furcatus* (Deflandre) is immediately overlying Helvetoglobotruncana helvetica Zone (Salaj and Gašpariková 1983). We place the *Marthasterites furcatus* (Deflandre) of the Late Turonian (part) in relation with the ammonite zones Romaticeras deverianum and Subprionocyclus neptuni.

In the upper part of the Helvetoglobotruncana helvetica T.R.Z., *Falsomarginotruncana schneegansi* (Sigal) emend. (Caron), *Falsomarginotruncana pseudolinneiana* (Pessagno), *Falsomarginotruncana coronata* (Bolli), together with *Whiteinella inornata* (Bolli) and *Falsotruncana maslakovae* Caron appear. It is practically the lower part of the Falsomarginotruncana schneegansi I.Z., for which Salaj and Gašpariková (1983) introduced the name Whiteinella inornata – Falsotruncana maslakovae Subzone. The subzone may represent in the Zone Helvetoglobotruncana helvetica T.R.Z. its uppermost part or in the Zone Falsomarginotruncana schneegansi its lower part.

As far as the problem of Middle Turonian stratigraphy is concerned, it should be mentioned that in some areas e.g. of Brasil (the Sergipe Basin) the species *Helvetoglobotruncana helvetica* (Bolli) and Middle Turonian index species of the genus *Dicarinella* are missing. Koutsoukos and Bengtson, (1993) defined for Middle Turonian shallow-water sediments the planktonic Hedbergella aprica – Hedbergella baltica Zone (correctly is coresponding to the term Whiteinella aprica – Whiteinella baltica Zone). In it, there are abundant benthic species of the Valvulineria sp. B – Gavelinella berthelini – plummerae – reussi plexus Zone.

Thus, it is generally confirmed that the variation in zonal divisions of sedimentary series is caused by the depth factor of the sea under which these were deposited. This was shown distinctly in the morphology of planktic foraminifers in individual depth zones as indicated by Bailey and Hart (1979), Caron and Homewood (1983) and Salaj (1987).

Late Turonian. This time section corresponds to the Falsomarginotruncana schneegansi I.Z., originally defined by Dalbiez (1955). We consider as insuitable the application of the "Marginotruncana" sigali Zone in the sense of Barr (1972) and/or Caron (1985) to the Late Turonian since these authors interpret the index species as more or less double-keeled. The one-keeled form of the species *Caronita sigali* (Reichel) are bound in their occurrence to the upper part of the Helvetoglobotruncana helvetica Zone only and never surpass its upper boundary. This double-keeled form described by Barr, 1972 represents a new species within the genus *Falsomarginotruncana,* for which we introduce the name *Falsomarginotruncana barri* n. sp.

It is evident that the association of planktic foraminifers of the Whiteinella inornata-Falsotruncana maslakovae Subzone (Tab. 1) reaches up to the lower part of the Late Turonian. Its upper boundary is determined by the appearance of the species *Dicarinella renzi* (Gandolfi) emend. (Salaj and Samuel, 1966) as defined by Salaj and Gašpariková (1983).

The next Late Turonian Falsomarginotruncana renzi Subzone thus would correspond to the uppermost part of the ammonite Romaniceras deverianun Zone and to the lower part of the Subprionocyclus neptuni Zone. The uppermost Late Turonian Dicarinella primitiva Subzone would correspond to the upper part of the Subprionocyclus neptuni Zone.

The rich associations of foraminifers of these zones are described by Salaj and Gašpariková (1983) and Salaj (1980, 1986, 1996), to which we also refer.

The richest association of Late Turonian planktic foraminifers as to genera, species and variability is mostly represented in North Africa in Tunisia. An association less abundant as to genera, but relatively also very rich in term of the number of specimens occurs in the Late Turonian of the Western Carpathians of Slovakia, for instance, in the Kysuca sequence of the Klippen Belt (Scheibnerová 1963) and in the Late Turonian of the Manín as well as Klape unit (Salaj 1962, 1995, Salaj and Samuel 1963, 1966, 1984). The species *Falsomarginotruncana schneegansi* (Sigal) emend. (Caron), *Falsomarginotruncana coronata* (Bolli), *Falsomarginotruncana renzi* (Gandolfi) emend. (Salaj and Samuel), *Falsomarginotruncana coldreriensis* (Gandolfi) and *Dicarinella primitiva* (Dalbiez) prevail. In the Late Turonian of the Western Carpathians there is also a rich association of benthic foraminifers (Salaj and Samuel 1966). The species *Dicarinella praeconcavata* n. sp. is found in the Late Turonian sporadically in Tunisia, the Western Carpatians of Slovakia, also in the Bohemian Cretaceous Basin. The species described by Robaszynski *et al.* (1990) as *Dicarinella concavata* (Brotzen) has not been found in the studied areas. The first occurrence of the species *Concavatotruncana concavata* (Brotzen) is noted from the Coniacian base (de Klasz 1962, Salaj 1980, Salaj and Gašparikova 1983).

Upper Turonian in the Bohemian Cretaceous Basin (BCB) belongs to the uppermost part of the Jizera Formation

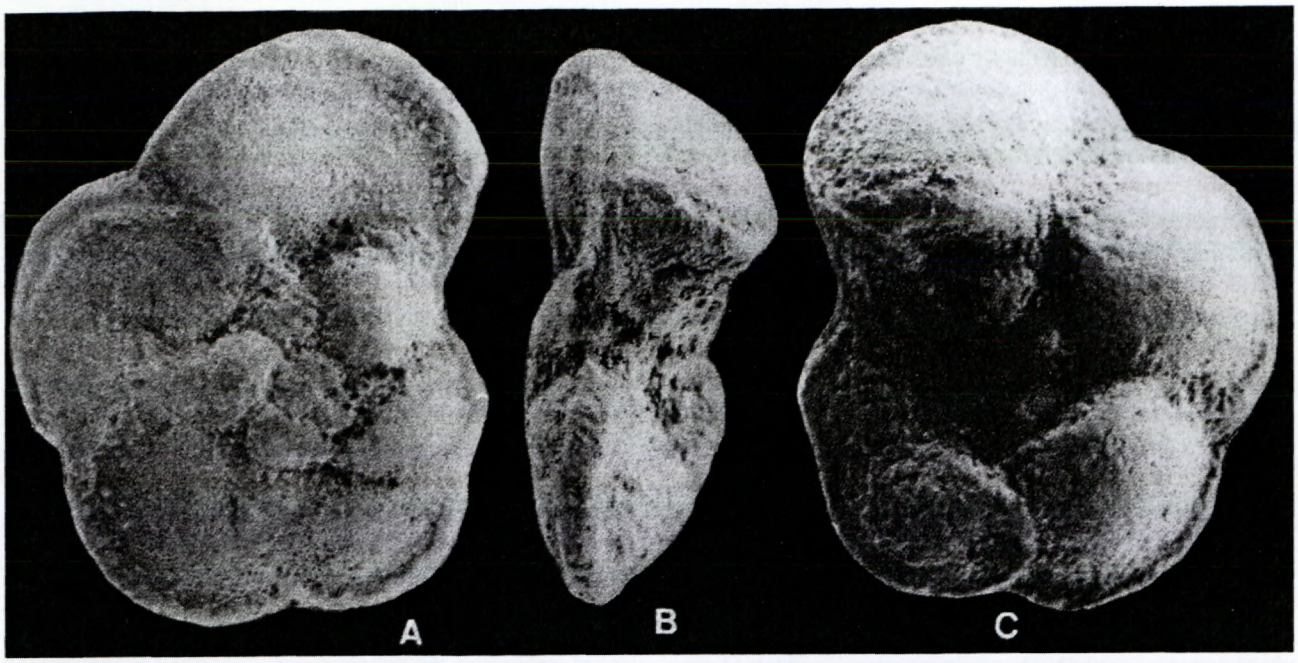


Fig. 1. ***Concavatotruncana praeconcavata*** **n. sp.**
Sample HMT 610, Aleg Formation, Late Turonian, Loc.: Kalaat Senan. x 130 (from Robaszynski *et al.* 1990, p. 356–357, Pl. 41, fig. 5a–c)

and to the main part of the Teplice Formation as shown by lithology. In the western part of the BCB the upper part of the Jizera Formation is developed as marlstones. Between this formation and the overlying limestones of the Teplice Formation a lithological boundary occurs as a bed of clayey limestones (about 0.1 m thick) known as "Coprolite Bed". Its lower boundary is sharp and erosive. The "Coprolite Bed" is characterized by an increased content of glauconite, phosphatic nodules and phosphatized fossil remains and coprolites.

Macrofossils of the Teplice Formation include e.g. *Scaphites geinitzi* d'Orb., *Inoceramus costellatus* Woods, *Mytiloides labiatoidiformis* (Tröger), *M. incertus* (Jimbo) and *M. striatoconcentricus* Gümbel (Čech *et al.* 1996).

In the planktic associations of Foraminifera non-keeled genera predominate such as *Hedbergella*, *Whiteinella*, and *Heterohelix*. The double or one-keeled species characteristic for the upper part of the Jizera and Teplice formations are as follows: *Falsomarginotruncana coronata* (Bolli), *Falsomarginotruncana schneegansi* (Sigal) emend. Caron, *Falsomarginotruncana pseudolinneiana* (Pessagno), *Marginotruncana marginata* (Reuss) emend. Jírová, *Caronita turona* (Olbertz), *Falsomarginotruncana barri* n. sp., and rarely *Concavotruncana praeconcavata* n. sp.

The species *Falsomarginotruncata schneegansi* occurs rarely in the BCB. This is why we use the species *Falsomarginotruncana coronata* (Bolli) as an index fossil in the Late Turonian from the uppermost part of the Jizera Formation and of the larger part of the Teplice Formation (Štemproková 1983, Hradecká 1999). Similarly the species *F. coronata* was used for the stratigraphical determination of the Late Turonian age in the Saxonian Cretaceous Basin (Wejda 1996). Marginotruncana coronata Zone is characteristic also for the Late Turonian in central Poland of the Middle Vistula river section (Peryt 1996).

Caronita turona (Olbertz) is found in the uppermost part of the Jizera Formation and in the lower part of the Teplice Formation.

The associations of foraminifers from the Upper Cretaceous of the BCB are characterized by rich benthic Foraminifera with a high variability of genera and species. Many species are important for stratigraphical distribution in the Late Turonian. They help to determine the age of the sediments along with planktic foraminfers. These are e.g. the genera *Tappanina* Montanaro Gallitelli (Štemproková-Jírová, 1963), *Praebulimina* Hofker (Štemproková-Jírová, 1975), *Eouvigerina* Brotzen (Štemproková-Jírová, 1963), *Gavelinella* Brotzen, *Lingulogavelinella* Malapris (Hradecká, 1996), *Gaudryina* d'Orb., *Neoflabellina* Bartenstein, (Herzogová, 1984, 1974).The boundary of the Turonian / Coniacian was determined in the BCB by the first appearance of the species *Eouvigerina serrata* (Chapman) (Štemproková-Jírová, 1981) and *Falsomarginotruncana angusticarinata* (Gandolfi).

SYSTEMATIC DESCRIPTION

Superfamily Globotruncanacea Brotzen, 1942
nom. correct. Salaj and Štemproková-Jírová, 2006
Family Globotruncanidae Brotzen, 1942

Genus ?*Concavatotruncana* Korchagin, 1982
Type species: *Globotruncana concavata* Brotzen, 1936.

Concavatotruncana praeconcavata n. sp.

1990 *Dicarinella concavata* (Brotzen); Gonzáles Donoso and Linares in Robaszynski *et al.*, p. 357, pl. 1, figs 5 a–c.

Type specimen: The holotype depicted in Robaszynski *et al.*, 1990, p. 357, fig. 5a–c.

Denomination: Composition of the words prae- and concavata.

Type level and type locality: Late Turonian, from HMT 610-3-1, Aleg Formation, Kaalat Senan area, Tunisia (cf. Robaszynski *et al.* 1990, p. 357).

This Upper Turonian species corresponds to the Coniacian ancestral species the *Concavatotruncana concavata* (Brotzen, 1936).

Description: Test very low trochospiral with the spiral side gently concave and the umbilical side only moderately convex (and not strongly convex as in *Concavatotruncana concavata*); evolute, consisting of the 3 to 3 1/2 whorls, equatorial periphery circular, weakly to lobulate, having two closely spaced keels which merge into a fine single keel on final one to two chambers. Chambers hemisphaerical, 5 1/2 to 6 in final whorl rapidly increasing in size. Sutures raised, curved on the spiral side moderarely curved (not sigmoidal) to radial moderately curved to radial (no depressed) on umbilical side. Umbilicus relativelly broad, moderately deep. Primary aperture umbilical to slightly extraumbilical without cover plate and accessory apertures.

Remarks: This new described species may be phyllogenetically related to the groups of the species as *Dicarinella primitiva* (Dalbiez). The new species is an intermediate species between the genus *Dicarinella* Porthault, 1970 and genus *Concavatotruncana* Korchagin, 1983 and we consider it as a direct ancestor of *Concavatotruncana concavata* (Brotzen).

We agree with Gonzáles Donoso and Linares (in Robaszynski *et al.* 1990, p. 356–357, figs. 1a–c, 2a–c) that some specimens of *Dicarinella* with a large porticus correspond to the intermediate form between this genus and primitive forms of the *?Archaeoglobigerina.*

Note: The problem of the validity of the genus *Concavatotruncana* Korchagin has not been so far finaly solved.

Caronita Salaj and Gašpariková, 1983

Type species: *Globotruncana sigali* Reichel, 1950.

Caronita mellegiana n. sp.

Type specimen: Figured on pl. 2, figs. 4–6 and deposited in the collection of J. Salaj, Geol. Institute of the Slovak akademy of Sciences, Bratislava.

Derivatio nominis: derived from the name Hammam Mellegue in the El Kef area, Tunisia.

Type level and type locality: No 12 from the section of Hammam Mellegue, the upper part of the Helvetoglobotruncana helvetica Zone.

Material: about 50 specimens from the sample No. 12, Hammam Mellegue.

Description: Test is distinctly one-keeled at all chambers, highly conical on the dorsal side with 3–3 1/2 whorls, each of which is with 5 1/2–6 chambers. Ventral side is straight to slightly concave. Sutures on the dorsal side demi-arc shape and raised, on the ventral side moderately bent to radial, depressed. Umbilicus is relatively large, moderately deep and with lips. Primary aperture extraumbilical to slightly umbilical.

Relation: The genus *Caronita* represents a species, which is related to the species *Caronita sigali* (Reichel) from the Tethyan realm as well as to the species *Caronita turona* (Olbertz) of the Boreal Realm as well as the Western Carpathians region of Slovakia.

Falsomarginotruncana Salaj, 1987, emend. Salaj and Štemproková, 2006

Type species: *Globotruncana schneegansi* Sigal, 1952, emend. Caron, 1977.

Falsomarginotruncana barri n. sp.

1972 *Globotruncana sigali* Reichel; F. T. Barr.

Type specimen: Figured in Barr, 1972, p. 23, Pl. 7, fig. 1a–c.

Derivatio nominis: after Prof. Dr. F. T. Barr.

Type level, type locality and material: See F. T. Barr 1972 (Northern Cyrenaica and less commonly in the northern Siste Basin).

Description: After Barr (1972) this species *Falsomarginotruncana barri* n. sp. (= "*Globotruncana sigali*") is characterized by 6 or 7 inflated petaloid chambers in its final whorl that rapidly and uniformly increase in size. However as is remarked by Barr (1972) this species has been described as having a single peripheral keel. The species has a double peripheral keel. However, on the earliest chambers of the final whorl there is sometimes a second weakly developed very closely spaced keel which then merges into a single keel on the later chambers.

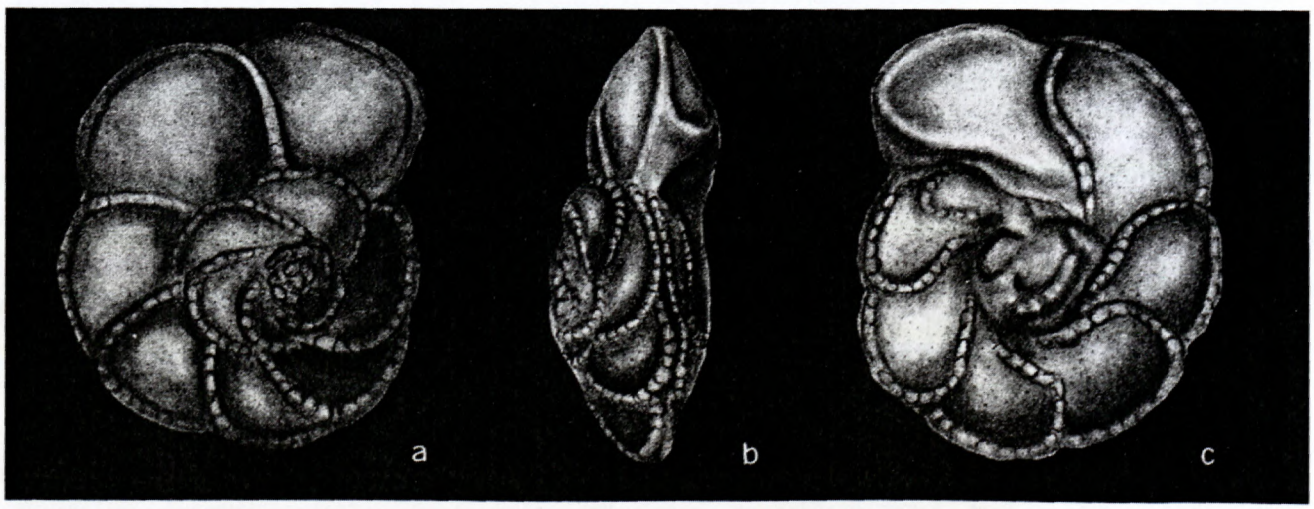


Fig. 2 ***Falsomarginotruncana barri*** **n. sp.**
Sample USNM 167882 subsurface, Jabal al Akhdar, northern Cyrenaica, Late Turonian. x 66 (from F.T. Barr 1972, p. 38–39, Pl. 7, figs. 1a–c).

The umbilicus is moderately broad, and the primary aperture is interiomarginal umbilical-extraumbilical.

Occurrence: The *Falsomarginotruncana barri* n. sp. appears for the first time at the top of the Helvetoglobotruncana helvetica Zone and is characteristic for the Upper Turonian to the lowermost Coniacian.

In agreement with Barr (1972) the *Falsomarginotruncana barri* n. sp. appears to be a direct ancestor of the Coniacian species *Falsomarginotruncana angusticarinata* (Gandolfi).

CONCLUSION

We studied the division of the Turonian into zones: this division was adopted with respect to the rule of priority.

The knowledge about the relation of the Thethyan and Boreal Turonian was derived from the development of palaeoassociations of planktic foraminifers in the course of the Turonian. The Early Turonian of the Western Carpathians is characterized by the absence of representatives of the genus *Whiteinella*, Pessagno. The development of associations of foraminifers in the lower and middle part of the Helvetoglobotruncana helvetica Zone is common both for the Thethyan and Boreal areas but index species are very often missing in the shallow-water sediments in extensive regions (e.g. in Brazil). Differences exist in the foraminiferal associations in both areas in the upper part of the Helvetoglobotruncana helvetica Zone, and mainly in the Late Turonian. The representation and variability of planktic genera and species is smaller in the Boreal Cretaceous in the Late Turonian. In the Bohemian Cretaceous Basin the Late Turonian sediments are rich in the representatives of the genera and species of benthic foraminifers.

The following new species are desribed: *Caronita mellegiana* n. sp. characteristic of the upper part of the Middle Turonian in the Thethyan area, the species *Concavatotruncana praeconcavata* n. sp. and *Falsomarginotruncana barri* n. sp. characteristic of the Late Turonian of the Thethyan and Boreal areas. It has been confirmed that the first occurrence of the species *Concavatotruncana concavata* (Brotzen) extends from the base of the Coniacian in both the areas.

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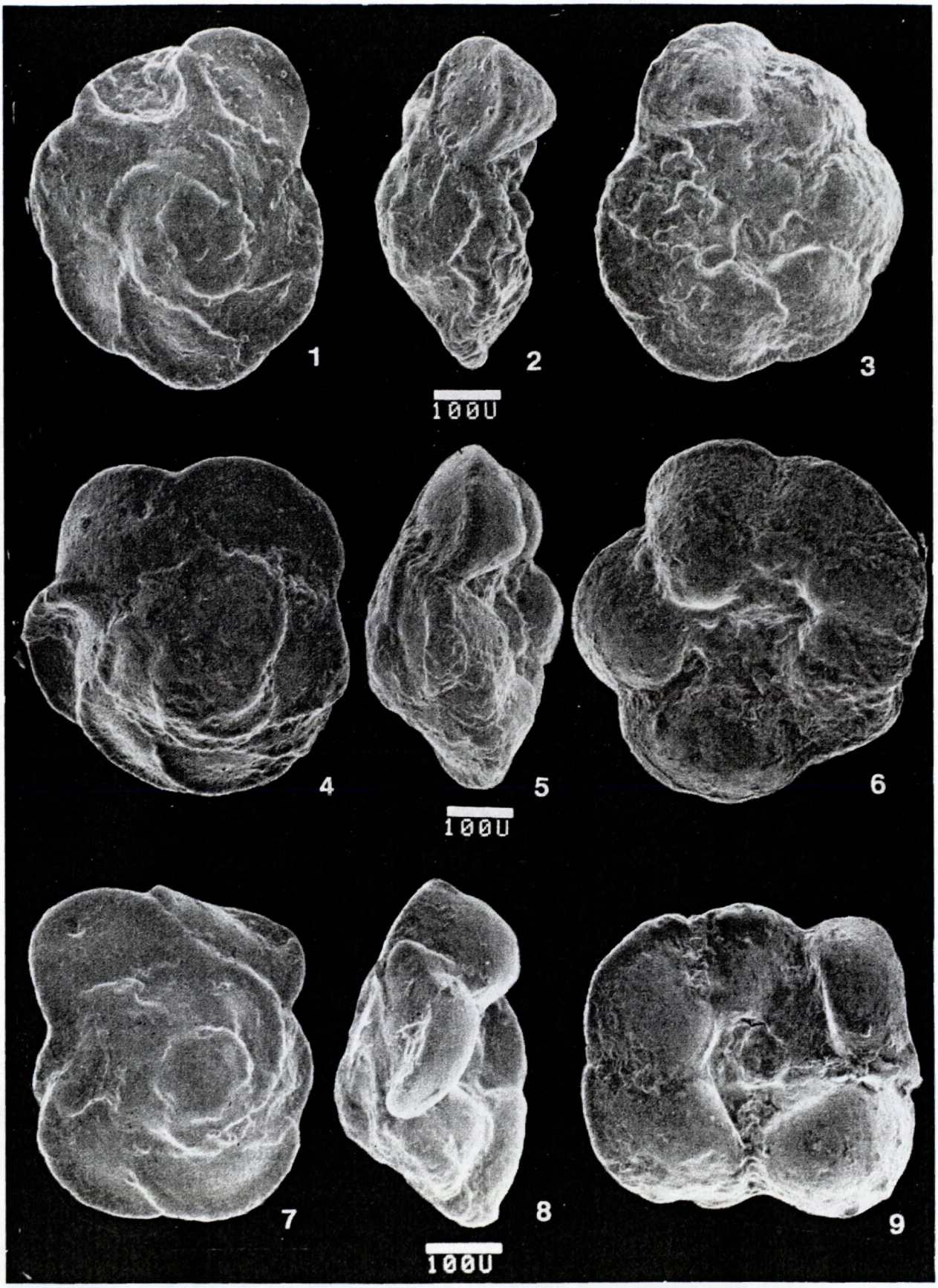


Plate 1

1–3 – *Dicarinella fusani* (Salaj and Samuel, 1977) x 60. Intermediate form between *Dicarinella biconvexa* (Samuel and Salaj, 1962) and *Caronita sigali* (Reichel). On the first and second chambers of the last whorl there are traces of the second keel,

4–6 – *Dicarinella fusani* (Salaj and Samuel,1977) x 60. More conical form,

7–9 – *Caronita sigali* (Reichel) x 65, x 65, x 60. Typical form only with one keel on the all chambers of the last whorl. Location: Hammam Mellegue, El Kef area (Tunisia). Age: Upper part of the Middle Turonian. Upper part of the Helvetoglobotruncana helvetica Zone, (Caronita sigali Subzone, the Bireno Formation). Sample No 23 (from the marls).

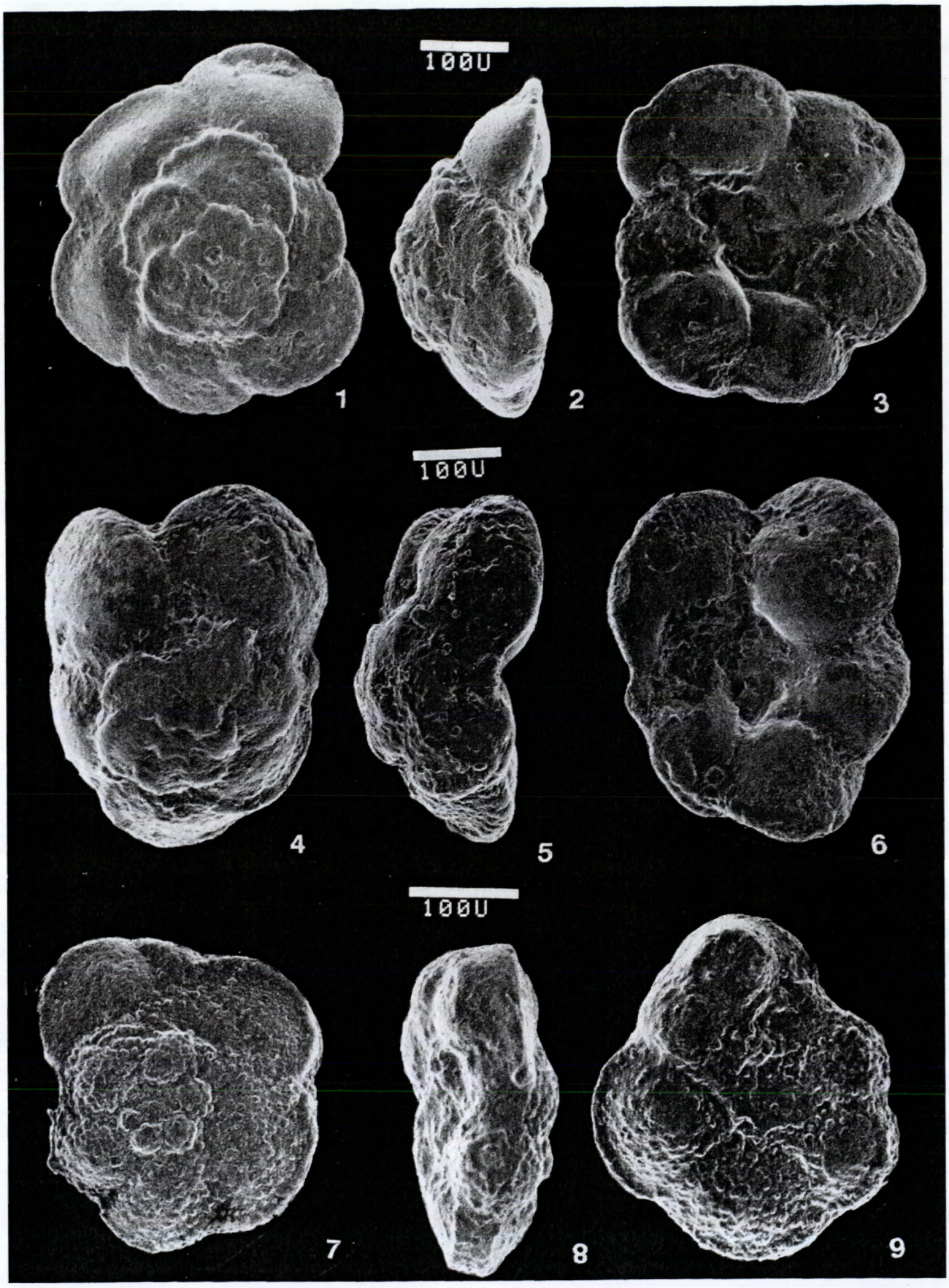


Plate 2

1–3 – *Caronita mellegiana* n. sp. x 75, paratype x 75,

4–6 – *Caronita mellegiana* n. sp. x 80, type species (= holotype). All (figs 1–6) specimens with well developed only one keel on all chambers of the last whorl. Location: Hamman Mellegue, El Kef area (Tunisia). Age: Upper part of the Middle Turonian Caronita sigali Subzone. The Bireno Formation. Sample No 23 (from the marls),

7–9 *Dicarinella imbricata* (Mornod, 1950) x 100. Last occurence of this species in the basal part of the Santonian, in the level with *Inoceramus (Platiceramus) siccensis* Pervinquière, with the apparition of the *Sigalia carpatica* Salaj and Samuel. Location: J. Fguira Salah, El Fahs area.

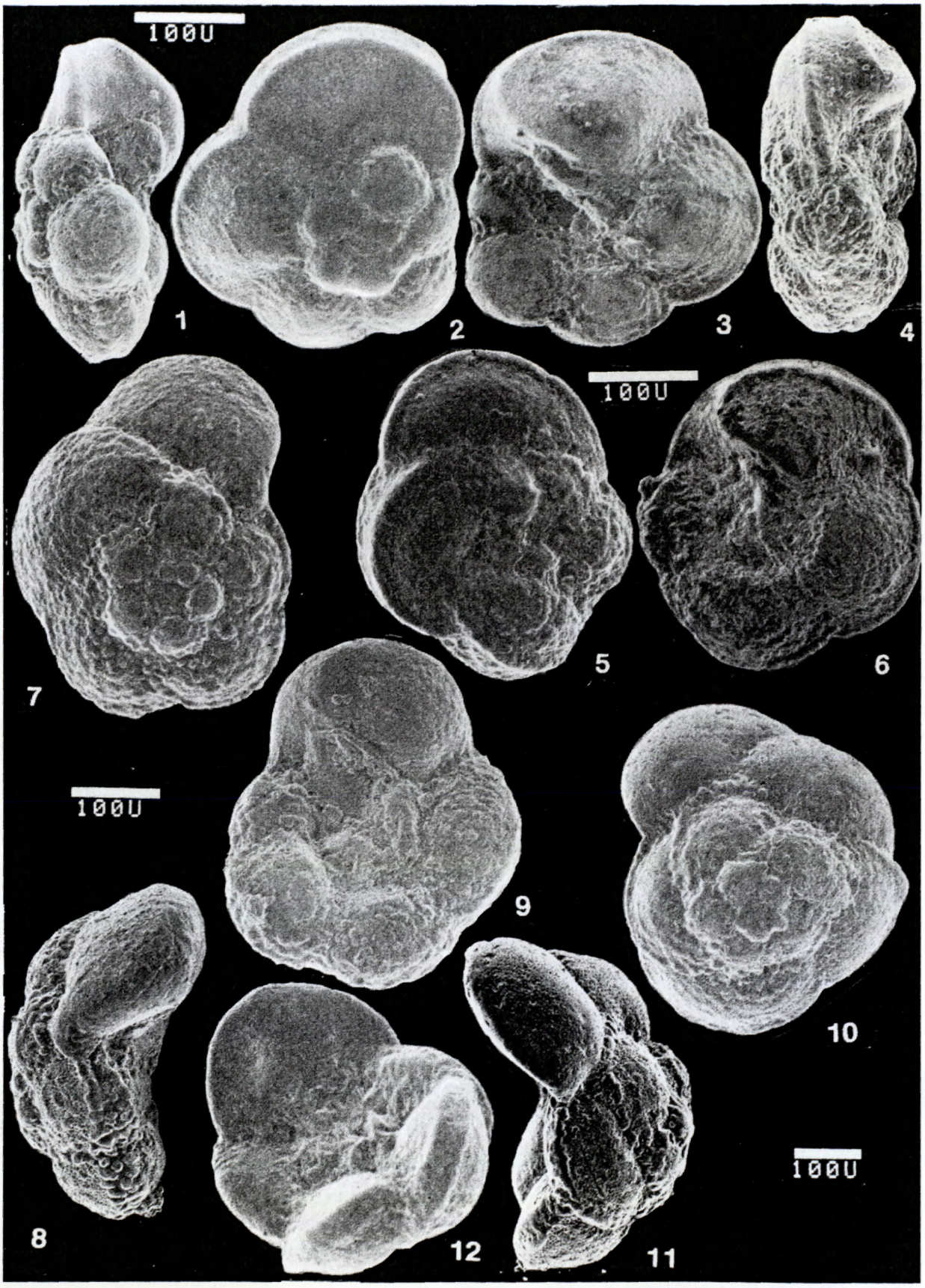


Plate 3

1–3 – *Globotruncana inornata* Bolli x 100. Location: Hamman Mellegue, El Kef area, Tunisia. Age: Basal part of the Falsotruncana schneegansi Zone. Top of the Middle Turonian,

4–6 – *Globotruncana repanda* Bolli x 100. Location: Hamman Mellegue, El Kef area (Tunisia). Age: Basal part of the Falsotruncana schneegansi Zone. Top of the Middle Turonian,

7–11 – *Globotruncanella praehavanensis* Salaj and Gašpariková x 60. Location: J. Fguira Salah. Age: Middle- Upper Coniacian Globotruncanella praehavanensis Zone.

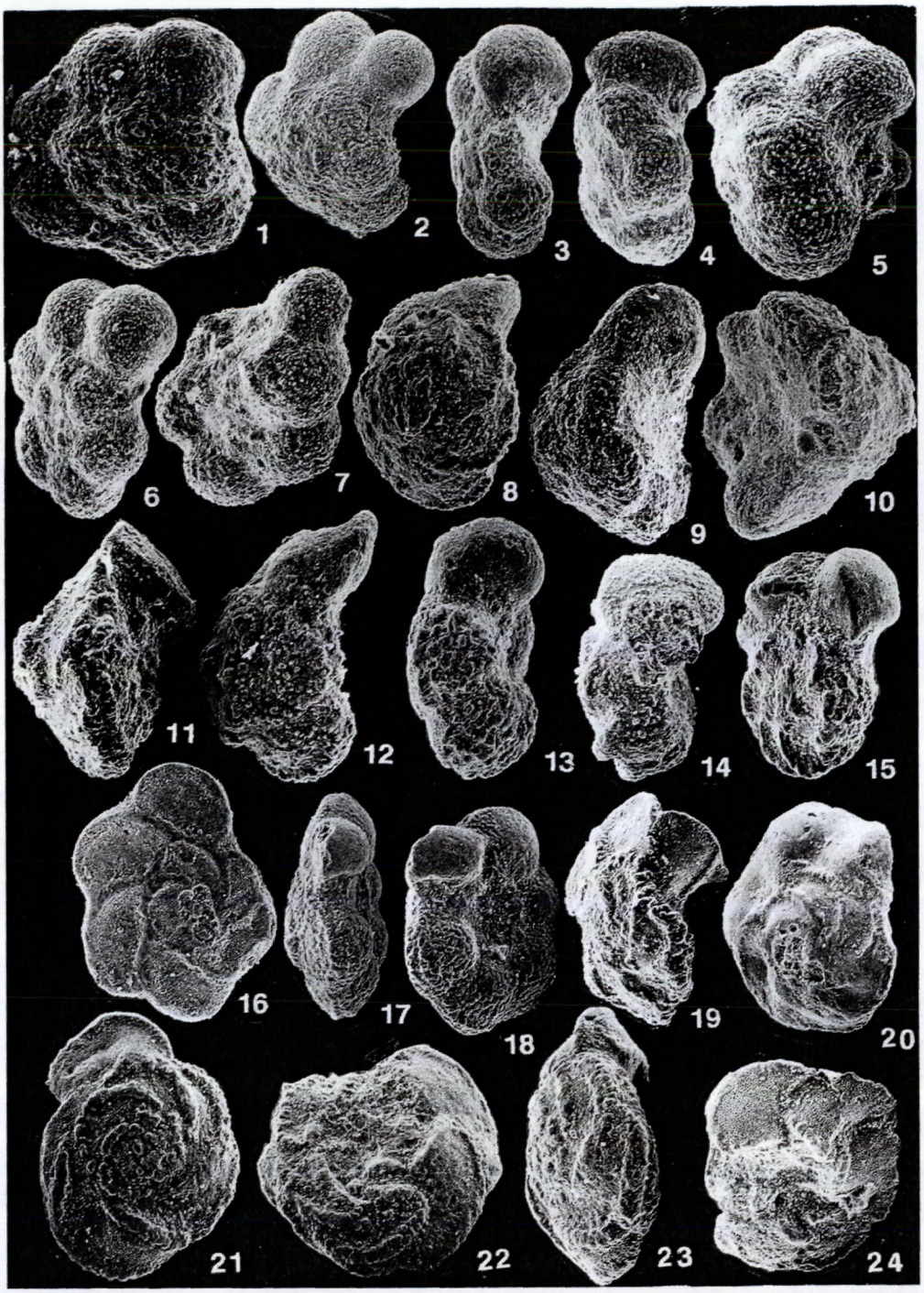


Plate 4

1–3, 6–7 – *Whiteinella gigantea* (Lehmann) x 70. Location: J. Fguira Salah (El Fahs area, Tunisia). Age: Lowermost Turonian Whiteinella gigantea- Dicarinella imbricata Zone. The Bahloul Formation. Sample No 122b (from the marls),

4 – Intermediate form between *Whiteinella gigantea* (Lehmann) and *Helvetoglobotruncana helvetica* (Bolli) x 80, Location: J. Fguira Salah, Sample No 122,

5 – *Whiteinella paradubia* (Sigal) x 80. Location: J. Fguira Salah. Age: Lowermost Turonian. Sample No 122b,

8–9 – *Dicarinella oraviensis* (Scheibnerová) x 80, x 85. Location: J. Fguira Salah. Age: Middle Turonian, Helvetoglobotruncana helvetica Zone, Dicarinella oraviensis Subzone). Sample No 8.

10 – *Dicarinella turbinata* (Reichel) x 80. Location: J. Fguira Salah. Sample No 8,

11 – *Dicarinella biconvexa* (Samuel and Salaj) x 80. Location: J. Fguira Salah. Age: Middle Turonian Helvetoglobotruncana helvetica Zone (Dicarinella biconvexa Subzone). Sample No 10,

12 – *Dicarinella trigona* (Scheibnerová) x 120. Location: J. Fguira Salah. No 8,

13–15 – *Helvetoglobotruncana helvetica* (Bolli) x 80, x 50, x 50. Location: J. Fguira Salah. Sample No 10,

16–18 – *Marginotruncana canaliculata* (Reuss) x 60. Location: J. Fguira Salah. Age: Upper Turonian Falsomarginotruncana schneegansi Zone (Dicarinella renzi Subzone). Sample No Z–23,

19 – *Falsomarginotruncata sinuosa* (Porthault) x 60. Location: J. Fguira Salah. Age: Upper Turonian Falsomarginotruncana schneegansi Zone (Dicarinella renzi Subzone). Sample No Z–33,

20, 24 – *Falsomarginotruncana undulata* (Lehmann) x 60. Location: J. Fguira Salah. Age: Upper Turonian Falsomarginotruncana schneegansi Zone (Concavatotruncana primitiva Subzone). Sample Z–2003,

21–23 – *Falsomarginotruncana sinuosa* (Porthault) x 70. Location: J. Fguira Salah. Sample No Z–23.

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SYSTEMATIC PROBLEMS OF SOME GENERA IN THE SUPERFAMILY GLOBOTRUNCANACEA BROTZEN, 1942

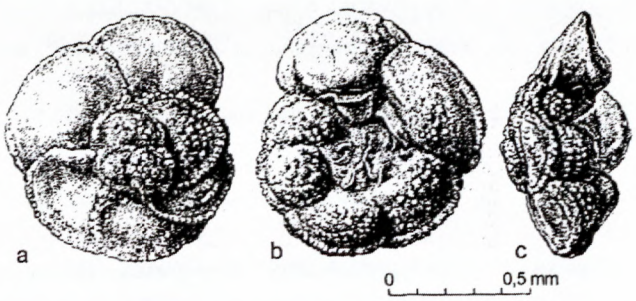
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Abstract: A modified system of planktonic foraminifers in superfamilies Rotaliporacea Sigal, 1958 and Globotruncanacea Brotzen, 1942 is proposed. The genera *Marginotruncana* Hofker, 1956 emend. and *Falsomarginotruncana* Salaj, 1987 emend. are revised.

INTRODUCTION

The study is focused on the superfamily Globotrucanacea and on taxonomic and systematic problems of the genus *Marginotruncana* Hofker, 1956 from the family Globotruncanidae Brotzen,1942 as well as on the genus *Falsomarginotruncana* Salaj, 1987 emend. Salaj and Štemproková-Jírová also from the family Globotruncanidae. Systematic position of these genera, as understood in the whole presented system in the superfamily Globotruncanacea Brotzen, 1942, results from their different phylogenetic relationships to various genera. This study of plantonic foraminifers was financed by the project MSM 1131 00 006 of the Charles University, Prague.



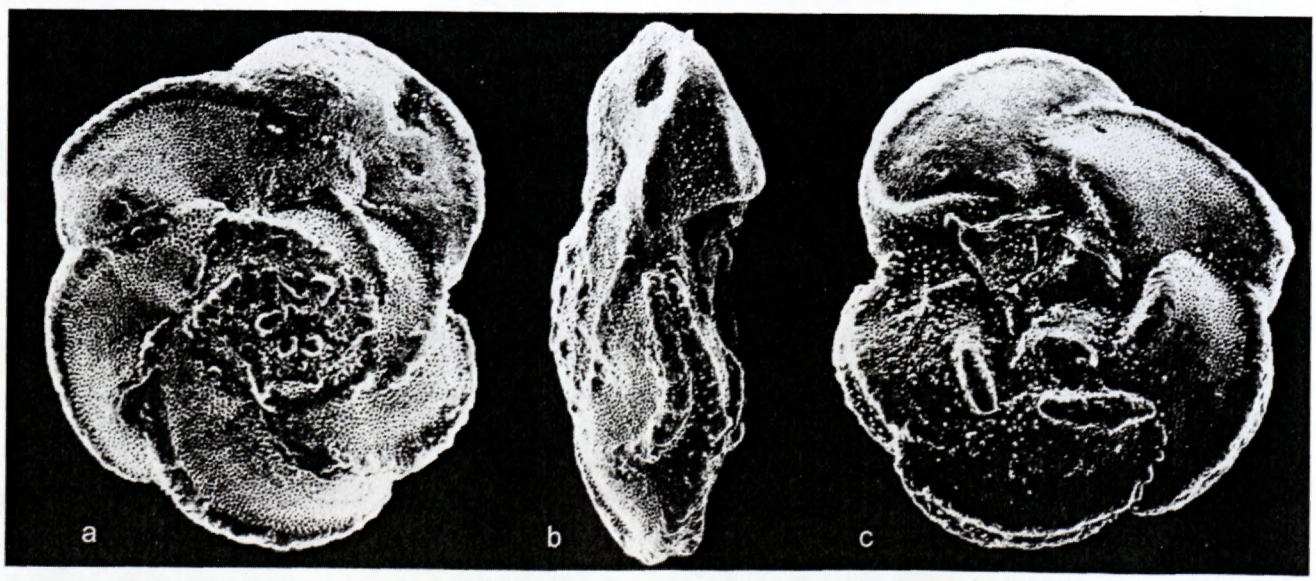
Figs. 1 a, b, c – Type species of *Falsomarginotruncana: Marginotruncana schneegansi* (Sigal, 1952) emend. Caron, 1977, p. 330–333, Pl. 1, figs. 1a–c.

PALEONTOLOGICAL DESCRIPTION

Genus *Falsomarginotruncana* Salaj, 1987, emend. Salaj and Štemproková-Jírová

Type species: *Marginotruncana schneegansi* (Sigal, 1952) emend. Caron, 1977, p. 330–333, Pl. 1, figs. 1–9.

Syn.
1990 *Marginotruncana (Falsomarginotruncana) schneegansi* (Sigal); Robaszynski *et al.*, p. 317, 319.
1990 *Dicarinella (Falsomarginotruncana)* sp. cf. *Marginotruncana schneegansi* (Sigal); Robaszynski *et al.*, p. 317, fig. 25.



Figs. 2 a, b, c – *Falsomarginotruncana sinuosa* Porthault, 1970 in Robaszynski, Caron et E.V.G.P.F. 1979, p. 148, Pl. 74, figs. 1a–c.

Diagnosis: Test trochospiral, biconvex to planoconvex. Equatorial periphery slightly lobulate to subcircular. Periphery of chambers formed by two well developed keels separated by imperforate peripheral band, chambers angular truncate, angular rhomboids or hemisphaerical (no globularly inflated on the dorsal side). Sutures more sigmoidal, raised on the umbilical and the spiral sides. Mostly developed typical sigmoidal sutures are present in species youngest in development as e.g. *Falsomarginotruncana sinuosa* (Porthault) and *Falsomarginotruncana tarfayensis* (Lehmann). Primary aperture extraumbilical – umbilical. Umbilicus large – 1/2 to 1/3 of the maximum test diameter. Successively following apertures are bordered by triangular portici which can weld with infralaminal accessory aperture in the centre. In some cases, true tegilla with infralaminal and intralaminal accessory apertures can be present along with extraumbilical – umbilical primary aperture.

Note: After Robaszynski *et al.* (1990, p. 318) "*Falsomarginotruncana* is therefore an appropiate name for joining, in a phylogenetic subgenus, a group of forms derived from *Whiteinella*, including *Marginotruncana (Falsomarginotruncana) schneegansi* (Sigal) from the morphological point of view they belong to the genera *Praeglobotruncana*, *Dicarinella* and *Marginotruncana* (Fig. 25)".

Stratigraphic range: the Upper part of the Middle Turonian to Santonian.

The species included by the authors to the genus *Falsomarginotruncana* Salaj, 1981 emend. are as follows:

Falsomarginotruncana angusticarinata (Gandolfi, 1942),
Falsomarginotruncana coronata (Bolli, 1945),
Falsomarginotruncana coldreriensis (Gandolfi, 1942) syn.: *Falsomarginotruncana renzi* (Gandolfi) emend. Caron, 1966,
Falsomarginotruncana desioi (Gandolfi, 1942),
Falsomarginotruncana paraconcavata (Porthault, 1970),
Falsomarginotruncana pseudolinneiana (Pessagno, 1967),
Falsomarginotruncana renzi (Gandolfi, 1942) emend. (Salaj and Samuel, 1966),
Falsomarginotruncana schneegansi (Sigal, 1952) emend. (Caron, 1977),

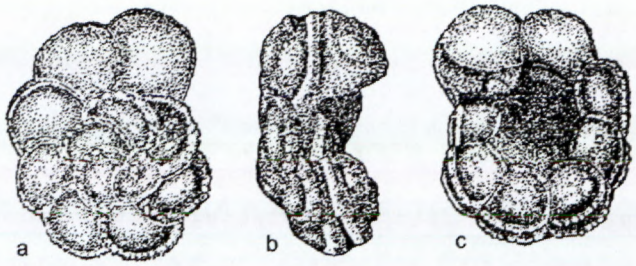
Intermedial forms to *Marginotruncana*

Falsomarginotruncana sinuosa (Porthault, 1970),
Falsomarginotruncana tarfayensis (Lehmann, 1963),
Falsomarginotruncana undulata (Lehmann, 1963),
Falsomarginotruncana undulata lehmanni (Ion, 1983),
Falsomarginotruncana tricarinata (Quereau) sensu Ion, 1983 described as *Globotruncana tricarinata* (Quereau).

Genus *Marginotruncana* Hofker, 1956, emend.

Type species: *Rosalina marginata* Reuss, 1845, neotype defined by Jírová, 1956, p. 241–242, Tab.1, figs. 1a, b, c.

Description: Test trochoidal, frequently biconvex, sometimes planoconvex with well developed double keel, 5 to 8 globular hemispherical usually globularly inflated chambers. Keels separated by a imperforate peripheral band,

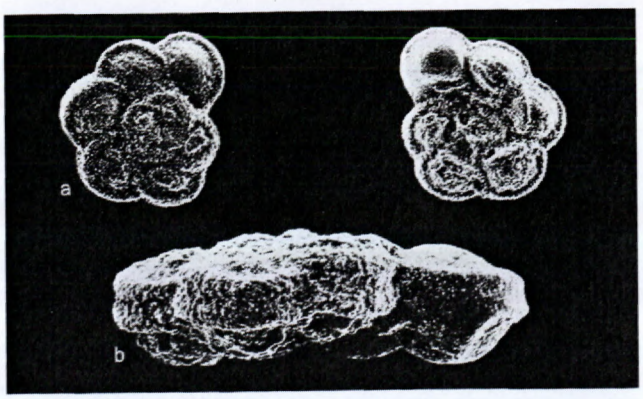


Figs 3 a, b, c – *Marginotruncana marginata* (Reuss, 1845) emend. Jírová, 1956, neotype, Lužice, p. 253, figs. 1a–c.

often narrow. Sutures depressed, appearing radial to slightly sigmoidal, on the umbilical side bordered often by U-shaped rims. Umbilicus shallow, from less than 1/4 to 1/3 of the maximum diameter of the test. Primary aperture extraumbilical – umbilical to nearly umbilical in position highly arched, with portici and with infralaminal accessory supplementary apertures.

Emendations of Pessagno (1967) and Porthault (1970) are not accepted for this genus by us (more sigmoidal sutures are characteristic of the genus *Falsomarginotruncana* Salaj, 1987, emended).

Variation of *Marginotruncana marginata* (Reuss) from the type locality (Štemproková-Jírová 1970): Morphological features of *Marginotruncana marginata* vary considerably. The tests of many specimens are slighty convex approximately equally on dorsal and umbilical sides. Some specimens have the dorsal side slightly less convex than the umbilical one, some of them are shaped reversely. The tests are rarely inflated so that they approach *Marginotruncana globigerinoides* (Brotzen). The sutures on the umbilical side are either radial or slightly sigmoidal. Many specimens have radial and slightly sigmoidal sutures in a variable ratio. Commonly the earlier chambers on the last whorl have radial sutures. The later ones are slightly sigmoidal. Most of the specimens have distinct keels. On the more inflated chambers of the type similar to *Marginotruncana globigerinoides* (Brotzen) the keels are less indistinct. Keels on the test of most specimens are close to each other, only some of them have keels in larger distances. Some specimens lack the keels on the last chamber, others have only a dorsal keel. Other specimens possess a ventral keel on the last chamber which is obliquely curved toward the ventral side of the test.



Figs. 4 a, b, c – *Marginotruncana marginata* (Reuss, 1845), emend. Jírová 1956 – topotype
Lužice, in Robaszynski, Caron et E.V.G.P.F. 1979, p. 108, Pl. 63.

Differences: The genus *Marginotruncana* Hofker, 1956, emend. has not strongly developed sigmoidal sutures thus mainly differing from the genus *Falsomarginotruncana* Salaj, 1987, emend. from which it also differs in its hemi-arcuate and spherically inflated chambers. The phylogenetic origin of both genera is derived from *Whiteinella* Pessagno, 1967 and from the genus *Dicarinella* Porthault, 1970. A similar idea is presented by Robaszynski *et al.* (1990) too.

Stratigraphic range: Middle Turonian to Santonian

The species included by the authors to the genus *Marginotruncana* Hofker, 1956 emend. are as follows:

?*Marginotruncana bouldensis* Pessagno, 1967,
Marginotruncana canaliculata (Reuss, 1854),
?*Marginotruncana concavata* (Brotzen, 1934), emend. Kuhry, 1970,
Marginotruncana cretacea (d'Orbigny, 1940) ?syn.,
Marginotruncana globigerinoides (Brotzen, 1936),
Marginotruncana linneiformis Hofker, 1956,
Marginotruncana marginata (Reuss, 1845), emend. Jírová, 1956, Syn. *Marginotruncana culverensis* (Barr, 1962),
Marginotruncana paraventricosa (Hofker, 1956),
Marginotruncana primitiva (Dalbiez, 1955) and
Marginotruncana praeschneegansi Salaj, 1987.

SYSTEMATIC DESCRIPTION

The suborder Globigerinina

The suborder Globigerinina Delage et Hérouard, 1896 sensu Simmons, Boudagher-Fadel, Banner and Whittaker, 1997 with superfamily Favusellacea Longoria, 1974 (nom. corr.) emend. Banner and Desai, 1988 (with Conoglobigerinidae Simmons *et al.*, 1997 and Favusellidae Longoria, 1974) and superfamily Globigerinacea Carpenter, Parker and Jones, 1862 (with Praehedbergellidae Banner et Desai, 1988, Schackoinidae Pokorný, 1958, Hedbergellidae Loeblich and Tappan, 1961 and Planomalinidae Bolli, Loeblich et Tappan, 1957) with the descriptions of individual genera and species is given in detail in the work by Boudagher-Fadel M. K., Banner F. T., Whittaker J. E., Simmons M. D., Taylor H., 1997 to which we refer. Some taxonomic problems and synonymic of some species of the mentioned genus will be discussed later in another publication.

Suborder Globotruncanina

We range in this new suborder of planktonic more or less Globotruncanoid foraminifers the superfamilies Rotaliporacea Sigal, 1958 and Globotruncanacea Brotzen, 1942 with the following families and genera:

Superfamily Rotaliporacea Sigal, 1958
Family Ticinellidae Longoria, 1974 nom. transl.

Genus *Ticinella* Reichel, 1950
Type species: *Anomalina roberti* Gandolfi, 1942.

Genus *Clavihedbergella* Banner et Blow, 1959
Type species: *Hastigerinella subcretacea* Tappan, 1943.

Genus *Biticinella* Sigal, 1956
Type species: *Anomalina breggiensis* Gandolfi, 1942.

Genus *Claviticinella* Banner, 1982
Type species: *Claviticinella digitalis* Banner, 1982.

Family Rotaliporidae Sigal, 1958

Genus *Rotalipora* Brotzen, 1942
Type species: *Rotalipora turonica* Brotzen, 1942, emend. Solakius et Salaj, 1987.

Genus *Thalmanninella* Sigal, 1948
Type species: *Thalmanninella brotzeni* Sigal, 1948.

Genus *Anaticinella* Eicher, 1973
Type species: *Globorotalia? multiloculata* Morrow, 1934. (syn. *Pseudoticinella* Longoria, 1973 and *Pseudorotalipora* Ion, 1983).

Note: *Thalmanninella* Sigal, 1948 is considered as a synonym of the genus *Rotalipora* Brotzen, 1948 by most authors. Substantiation of using both genera and its validity was pointed out by Maslakova (1961), Salaj and Samuel (1966), Solakius and Salaj (1987) a.o.

Superfamily Globotruncanacea Brotzen, 1942
Family Whiteinellidae Salaj, 1987

Genus *Whiteinella* Pessagno, 1967
Note: We consider that *Whiteinella gigantea* (Lehmann, 1963) is not a synonym of *Whiteinella archaeocretacea* Pessagno, 1967 as it is mentioned by Robaszynski *et al.* (1979). If these taxa are identical, *Whiteinella archaeocretacea* Pessagno, 1967, must be synonymous with *Whiteinella gigantea* (Lehmann, 1963). In this case the genus *Whiteinella* Pessagno, 1967 must be nomen nudum. However, distinct morphological differences and different stratigraphic spans exclude the discussion about this possible synonymy: *Whiteinella archaeocretacea* (Pessagno) does not occur in Upper Cenomanian-Lower Turonian strata. The first appearance of this species together with *Whiteinella inornata* (Bolli) is in the uppermost part of the Helvetoglobotruncana helvetica Zone.

In agreement with Salaj and Gašpariková (1983, p. 593) and Robaszynski *et al.* (1990) we stressed (in the sense of the International Code of Zoological Nomenclature) the validity of the name *Whiteinella gigantea* (Lehmann, 1963) and the name of the Whiteinella gigantea Zone of Bolli (1966) for the uppermost Cenomanian and Lower Turonian.

Family Falsotruncanidae nov. fam.

Type genus: *Falsotruncana* Caron, 1981
Type species: *Falsotruncana maslakovae* Caron, 1981, p. 66, Tab. 2, figs. 1a–d.

Diagnose corresponds to the description of the genus *Falsotruncana* Caron, 1981. Test with two keels, aperture umbilical-extraumbilical to periferal with narrow lips. Umbilicus without the portici and without the tegills. Umbilical sutures are radial.

Genus *Falsotruncana* Caron, 1981
Type species: *Falsotruncana maslakovae* Caron, 1981.

In this genus the important species for the biostratigraphy of the Upper Turonian are the following ones:

Falsotruncana loeblichae Caron, 1981,
Falsotruncana douglasi Caron, 1981,
Falsotruncana fguirensis Salaj, 1987.

Family Rotundinidae Bellier and Salaj, 1977 (syn. Praeglobotruncanidae Loeblich and Tappan, 1982)

Genus *Praeglobotruncana* Bermúdez, 1952
Type species: *Globorotalia delrioensis* Plummer, 1931.

Family Helvetoglobotruncanidae Lamolda,1976

Genus *Helvetoglobotruncana* Reiss, 1957, emend. Salaj, 1972
Type species: *Globotruncana helvetica* Bolli, 1951.

Family Globotruncanidae Brotzen, 1942

Genus *Dicarinella* Porthault, 1970, (syn. *Sigalitruncana* Korchagin, 1982)
Type species: *Globotruncana indica* Jacob et Sastri, 1950.

Note: In the Loeblich and Tappan (1988) genus *Dicarinella* is given among the genera of uncertain Status with their justification: "However, the original type species cannot be changed (ICZN), and the genus is unrecognizable on the basis of the type species" (pp. 698–699).

Genus *Marginotruncana* Hofker, 1956, emend. Salaj et Štemproková-Jírová, 2006
Type species: *Rosalina marginata* Reuss, 1845.
Neotype: *Globotruncana marginata* (Reuss) emend. Jírová, 1956.

Genus *Falsomarginotruncana* Salaj, 1987, emend. Salaj and Štemproková-Jírová, 2006
Type species: *Marginotruncana schneegansi* (Sigal, 1952), emend. Caron, 1977.

Genus *Globotruncana* Cushman,1927, emend. Longoria and Gamper, 1975
Type species: *Pulvinulina arca* Cushman, 1927.

Genus?*Concavatotruncana* Korchagin, 1982
Type species: *Rotalia concavata* Brotzen, 1934, lectotype Kuhry (1970).

Note: The authors suppose that the genus *Concavatotruncana* is not valid, because the type species probably belongs to the genus *Marginotruncana*. Robaszynski *et al.* (1990) preferred to call the forms with plano-convex chamber and slightly sigmoidal sutures as *Marginotruncana* sp. cf. *D. concavata* and *Marginotruncana* sp. cf. *D. primitiva*.

Genus *Contusotruncana* Korchagin, 1982
Type species: *Pulvinulina arca* Cushman n. sp. var. *contusa* Cushman, 1926.
(syn: Rosita Caron, Gonzáles Donoso, Robaszynski and Wonders, 1984 with the type species *Globotruncana fornicata* Plummer, 1931)

Genus *Radotruncana* El-Nagar, 1971, emend. Salaj, 1987
Type species: *Globotruncana calcarata* Cushman, 1927.

Genus *Kassabiana* Salaj and Solakius,1984
Type species: *Globotruncana falsocalcarata* Kerdany and Abdelsalam, 1969.

Genus *Caronita* Salaj and Gašpariková, 1983
Type species: *Globotruncana sigali* Reichel, 1950.

Note: Type species *Globotruncana sigali* Reichel, 1950 designed by Korchagin (1982) for his new genus *Sigalitruncana* has two keels (= cf. Loeblich and Tappan, 1988, p. 470: "peripheral keel formed by two rows of closely spaced pustules"; see Robaszynski *et al.* 1977, and Ion 1983), but this species originally described by Reichel (1950) has only one keel. This last species was designed by Salaj and Gašpariková (1983) as the type species of the genus *Caronita* which must be valid. On the contrary we put the species *Sigalotruncana sigali* (Reichel) in the concept of Korchagin (with two keels) to the synonym with *Dicarinella fusani* Salaj et Samuel, 1977 which is phylogenetically related to the ancestor of the younger species *Caronita sigali* (Reichel).

Genus "*Carpathoglobotruncana*" Ion, 1983
Type species: *Marginotruncana pileiformis* Lamolda, 1977.

Note: This genus is not valid (nomen nudum) for the reason that the type species of this genus is as synonym of *Caronita turona* Olbertz, 1942. For this reason the species described as *Carpathoglobotruncana neoschneegansi* by Salaj (1987) must be placed in the genus *Caronita* Salaj et Gašpariková (1983), too. Last time the species described as *Praeglobotruncana kalaati* Robaszynski *et al.* (1990) with one keel is a synonym of the species *Caronita neoschneegansi* (Salaj, 1987). A synonym of this latter species is *Sigalitruncana* sp. cf. *Marginotruncana* cf. *schneegansi* (Sigal sensu Robaszynski *et al.*, 1990, p. 317).

Genus *Globotruncanita* Reiss, 1957
Type species: *Rosalina stuarti* De Lapparent, 1918.

Genus ?*Archaeoglobigerina* Pessagno, 1967
Type species: *Archaeoglobigerina blowi* Pessagno, 1967.

Genus *Archaeoglobitruncana* Salaj et Maamouri, 1984
Type species: *Rugotruncana kefiana* Salaj et Maamouri, 1982.

Family Rugoglobigerinidae Subbotina, 1959, emend. Longoria et Gamper, 1984

Genus *Rugoglobigerina* Broennimann, 1952
Type species: *Globigerina rugosa* Plummer, 1927.

Genus *Rugotruncana* Broennimann, 1952, emend. Pessagno, 1967
Type species: *Rugotruncana tilevi* Broennimann, 1952.

Genus *Gansserina* Caron, Gonsales Donoso, Robaszynski et Wonders, 1984
Type species: *Globotruncana gansseri* Bolli, 1951.

Genus *Trinitella* Broennimann, 1952
Type species: *Trinitella scotti* Broenniman, 1952.

Genus *Costellagerina* Petters, El-Nakhal et Gamper, 1984
Type species: *Rugoglobigerina bullbosa* Belford, 1960.

Genus *Kassabella* El-Nakhal, 1984
Type species: *Loeblichella carteri* Kassab, 1976.

Family Helvetiellinidae Longoria et Gamper, 1984
Genus *Kuglerina* Broennimann et Brown, 1956, (syn. *Helvetiella* Longoria et Gamper, 1984)
Type species: *Rugoglobigerina rugosa rotundata* Broennimann, 1952.

Genus *Bucherina* Broennimann et Brown, 1956
Type species: *Bucherina sandidgei* Broennimann et Brown, 1956.

Family Globotruncanellidae Maslakova, 1964, nom. trans. Maslakova, 1978

Genus *Globotruncanella* Reiss, 1957 emend. Robaszynski *et al.* 1984
Type species: *Globotruncana havanensis* Voorwijk, 1937.

Genus *Abanthophalus* Bolli, Loeblich et Tappan, 1957
Type species *Globotruncana mayaroensis* Bolli, 1951.

CONCLUSION

Understanding of some systematic problems in the superfamily Globotruncanacea, mainly of the genus *Falsomarginotruncana* Salaj, 1987, emend. and *Marginotruncana* Hofker, 1956, emend. enables a more exact stratigraphic correlation of some Turonian and Coniacian species from different regions, especially from Tunisia, the Western Carpathian of Slovakia and from the Bohemian Cretaceous Basin. The study of systematic position of individual genera in superfamilies of Rotaliporacea Sigal, 1958 and Globotruncanacea Brotzen, 1942 considers not only their morphological features but also the phylogenetic relationships among individual genera.

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PALYNOLOGICAL CHARACTERISTICS OF PALAEOECOLOGICAL CHANGES DURING THE CENOMANIAN TRANSGRESSION

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Abstract: Palynological study of many profiles of the boreholes and outcrops of the Bohemian Cenomanian during last years provided rich material for palaeoecological conclusions. Characteristic changes of vegetation were namely caused by transgressive-regressive phases during the continuing Cenomanian transgression. It was possible to recognize different typical assemblages depending on various palaeoenvironment – fluvio-lacustrine, estuarine, marginal marine to outer neritic. We compared the palynomorphs from fluvio-lacustrine to marginal marine environment in two boreholes of the Peruc Member (Kc-1 Ledčice and Ln-1 Louny) of the Bohemian Cretaceous Basin and open marine conditions in the Main Quarry – Kotouč (Štramberk, Silesian unit, outer Western Carpathians). Both marine and terrestrial palynomorphs were used for the reconstruction of the palaeoenvironment.

INTRODUCTION

The reconstruction of vegetation and palaeoenvironment is complicated by redeposition, water and air transportation. The preservation of palynomorphs is sometimes poor as a response of different depositional conditions (i.e., oxygen depleted or anoxic zones, changes caused by sea-level fluctuations).

Basal Cretaceous sediments of the Bohemian Cenomanian were deposited in continental and marginal marine environment (mainly the Peruc Member sensu Čech *et al.* 1980) and subsequently due to continuing transgression in the open marine conditions (Korycany Member, lower Turonian of the Bílá Hora Formation).

The age of the upper, marginal marine part of the Peruc Formation, was identified on the basis of presence of triporate angiosperm pollen of Normapolles group (Pacltová 1966, Pacltová and Mazancová 1966) within the ammonite *Acanthoceras jukes-brownei* Zone. Most of the overlying sediments are deposited in open marine environment (*Calycoceras naviculare, Metoicoceras geslinianum* Zones after Čech *et al.* 1980).

MATERIAL AND METHODS

The examined samples represent a wide variety of lithological types ranging from sandstones, claystones to coal, and include continental, marginal marine and open marine sediments. Plant microfossils have been obtained from 32 samples of all lithological types, although the dark grey claystone and coal has generally yielded the best preserved and diverse assemblages. The sediments were treated using a standard palynological extraction technique involving HCl-HF-HCl and heavy liquid, $ZnCl_2$ treatment. Some of the samples (Ledčice, Štramberk) were sieved through 10 μm mesh size. Slides were prepared using glycerol gelatin as a mounting medium. Residues and slides are stored in the collection of the Institute of Geology AS CR and Department of palaeontology, Charles University, Prague.

We chose two boreholes Ledčice (Kc-1) and Louny (Ln-1) and one outcrop from the Štramberk (Main quarry Kotouč) with aim to demonstrate the importance of palynomorphs and other organic-walled rests (foraminifers, scolecodonts) for the reconstruction of changing lithological and paleoecological conditions.

ENVIRONMENTS

Most of the Bohemian Cenomanian sediments were prevailingly deposited in coastal facies. It is probably caused by the palaeogeographical conditions in various areas of the Bohemian Cretaceous basin. The character of assemblages is influenced by the sea-level fluctuations, climatic and palaeoenvironmental conditions. In this period several phases of transgression-regression are observed which influenced the changes of vegetation.

Depending on the environments of deposition the following palynomorphs of marine origin were obtained from the lithologically well defined sediments: acritarchs, chlorococcalean, prasinophyte, zygnematalean and other green algae, dinoflagellate cysts, foraminiferal linings, scolecodonts, and miscellaneous microfossils. Palynomorphs of terrestrial origin include spores and pollen, fungal spores, plant cuticles and tracheids, and coaly particles (highly carbonized plant debris). Palynofacies analysis is very important method for the determination of deposition (Traverse 1994, Batten 1996).

There are only some palynomorphs which can be used for stratigraphical purpose. Angiosperm pollen of the Normapolles group are one of the index microfossils. These elements are not present in all types of facies. They originate in the marginal facies (Pacltová 1990). Both angiosperm pollen and dinoflagellate cysts were used for biostratigraphical purpose in Štramberk. (Svobodová and Skupien unpublished data). We were able to confirm it during our common study of many outcrops and boreholes where the studied sediments are in the superposition (Svobodová 1988, 1992, Pacltová and Svobodová 1993, Uličný *et al.* 1997, Svobodová *et al.* 1998, Čech and Svobodová 1999 and many unpublished data). We can study the changes of the composition of the terrestrial as well as marine microfossils during both transgressive and regressive phases. Our observations of palynofacies character are in coincidence with the results of other authors (i.e. Wall *et al.* 1977, Bradford, Wall 1984, Lister and Batten 1988, Tappan 1980, etc.).

BOREHOLE KC-1 LEDČICE (N OF KRALUPY NAD VLTAVOU)

Palynomorph assemblages in the sediments of the Peruc Member in the borehole Kc-1 can be divided into two different associations according to the type of environment. Both upper claystones (depth 86.50–96.50 m) and lower ones (depth 102.50–111.00 m) were recorded in the studied borehole. The upper Cenomanian ammonite *Calycoceras* cf. *naviculare* (Mant.) was found in the sandstones of the Korycany Member on the locality Mšené situated very close to borehole Kc-1 (Klein and Soukup in Svoboda *et al.* 1964).

The upper claystones deposited in the mixed environment of the estuary, palynomorphs from the upper part of the borehole Kc-1 characterise the appearance of marine dinoflagellate cysts, agglutinated chitinous foraminifera linings. The maximum of marine dinocysts is recorded in the interval 86.50–90.80 m – it corresponds with estuarine conditions. Marginate genus *Cyclonephelium* is the most common here and indicating the sediments deposited in nearshore, unstable environments. Skolochorate type of dinocysts are represented by genera *Surculosphaeridium, Cleistosphaeridium, Spiniferites, Callaiosphaeridium, Achomosphaera.* These cysts typically possess longer and more delicate processes than nearshore forms and characterize more stable, open water conditions (Vozzhennikova 1965, Wall 1965). The fact that they are often broken suggests the unstable conditions and the transport by currents into the shallower environment. Acritarchs are also common, diversified genera of *Micrhystridium* and *Veryhachium* are present. Some prasinophytes i.e. *Pterospermella australiensis* (Deflandre et Cookson) Eisenack occur. The underlying sandy claystones (96.5 m) contain substantially less marine elements and the deposits are most probably connected with the deltaic conditions. The composition of dinocysts differ from above-mentioned, mostly ceratioid type of *Odontochitina operculata* (O. Wetzel) Deflandre et Cookson occurs. This form is common in the environment with rapidly changing salinity. Some non-marine algae (*Chomotriletes minor* (Kedves) Pocock, *Tetraporina*) also appear.

Spore and pollen assemblages represent the local flora which grew in the coastal margin. It is characterized by low species diversity and the presence of inaperturate pollen grains like *Classopollis* and *Taxodiaceaepollenites.* Pteridophyte (spores of Gleicheniaceae family prevail) and bryophyte spores (*Stereisporites, Cingutriletes*) are the most frequent microfossil group. Gymnosperm pollen – important halophytes of the Cheirolepidiaceae family *Classopollis classoides* (Pflug) Pocock et Jansonius and specimens of *Taxodiaceaepollenites* occur in this assemblage. The shrubby halophyte vegetation grew at the level of the upper tidal limit and on the surface of the salt marsh. The taxodiaceous conifers are suggested to represent trees growing in backswamp together with angiosperm taxa (angiosperm pollen both monocolpate *Liliacidites* and thick-walled tricolpate *Tricolpites barrandei* Pacltová, tricolporate *Perucipollis minutus* Pacltová are abundant, triporate pollen of *Complexiopollis* appear rarely). Yellow to brown structured fragments of plant tissue (cuticles and tracheids) of various size frequently occur.

Upper claystones were deposited in estuarine environment – tidal flat (Fig. 1). Lower claystones were deposited in the fluvio-lacustrine environment – meandering river (in lower part) and lake (in upper part of section).

Palynofacies of the lower part of the borehole, depth 103.4–110.5 m is characterized by the striking rise of the pteridophyte spores which are also highly diversified, forming 71–92% of the assemblage. Most abundant are the spores of Lycopodiaceae – *Retitriletes austroclavatidites* (Cookson) Döring *et al.* in Krutzsch 1963, *Camarozonosporites insignis* Norris, *Camarozonosporites ambigens* (Fradkina) Playford, Cyatheaceae - *Deltoidospora australis* (Couper) Srivastava, *Deltoidospora minor* (Couper) Pocock, Schizaeaceae – *Cicatricosisporites venustus* Deák, *Plicatella (Appendicisporites)*, Gleicheniaceae – *Gleicheniidites senonicus* Ross, *Ornamentifera echinata* Bolchovitina, *Clavifera triplex* (Bolchovitina) Bolchovitina. Thick-walled fern spores (e.g., *Gleicheniidites carinatus* (Bolchovitina) Bolchovitina, *Camarozonosporites*, *Deltoidospora*) represent upland vegetation. Other Pteridophytes e.g. Lycopodiaceae represent local swampy vegetation in an alluvial plain. Most gymnosperms are characterised by members of Pinaceae (*Parvisaccites radiatus* Couper, *Phyllocladidites*, *Podocarpidites*, *Alisporites*, *Pinuspollenites*) which are usually interpreted as growing on well-drained substrates (Axelrod 1986). Angiosperm pollen, tricolpate reticulate types (*Retitricolpites* spp.), psilate tricolporate *Perucipollis minutus* Pacltová, *Tricolporoidites subtilis* Pacltová and rare polyporates *Bohemiperiporis zaklinskae* Pacltová characterise fluvial deposits of alluvial valley. They form in the depth 109.5 m up to 22% of the total assemblage. Non-marine algal cysts referable to *Chomotriletes minor* (Kedves) Pocock, *Tetraporina*, *Schizocystia*, *Ovoidites* occur more frequently in the uppermost part of lower claystones and reflects fluvio-lacustrine origin of this layer. Coaly particles, frequently angular, of highly carbonized plant debris may origin from fire or from chemical alteration of plant debris, as happens in peats.

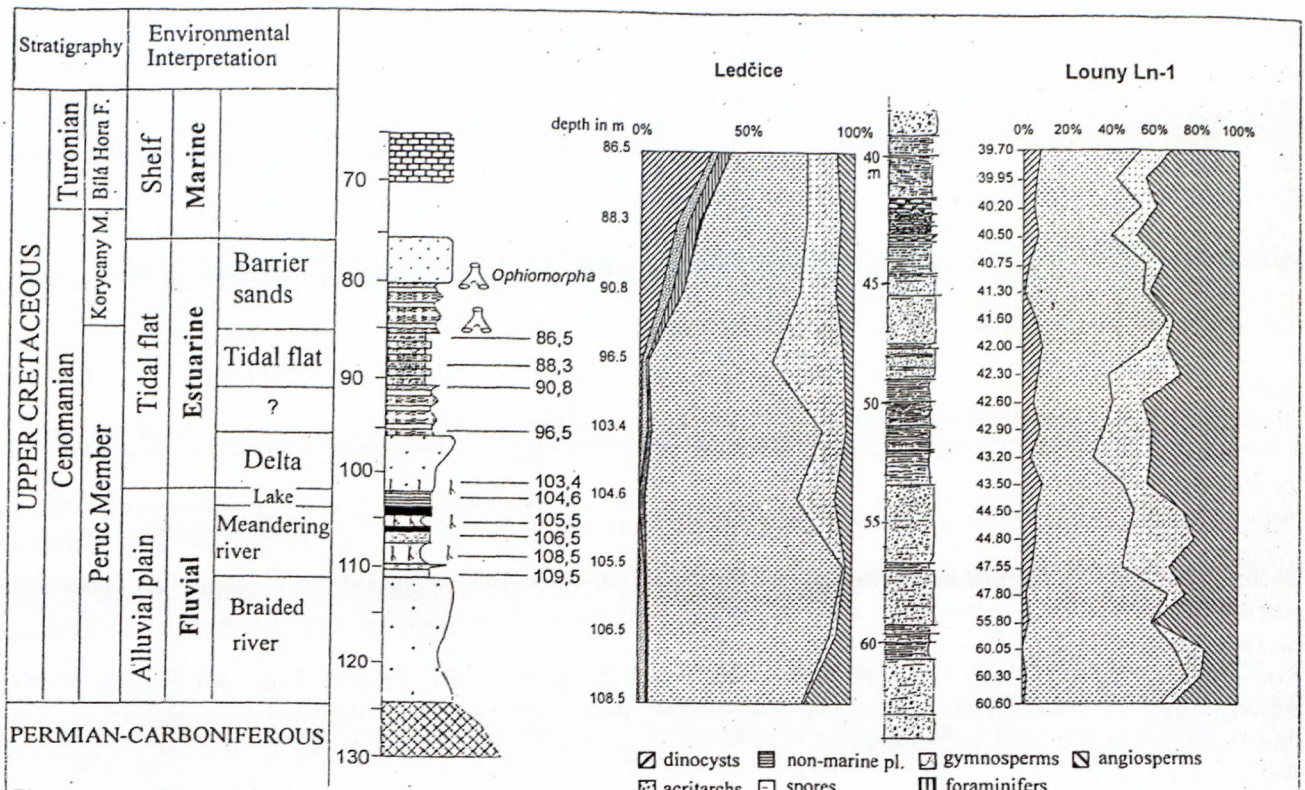


Fig. 1 Lithological profile of the boreholes and relative abundance of major palynomorph groups (modified after Čech, Svobodová 1999)

BOREHOLE LOUNY (LN-1)

Basal Cenomanian sediments are from the depth 60.00–60.70 m – black-grey sandy claystone with mica contain floral detritus with various spores of bryophytes and pteridophytes which prevail (*Gleicheniidites*, *Cicatricosisporites*, *Appendicisporites*, *Echinatisporites*). Gymnosperm pollen – *Cycadopites*, *Cedripites*, *Alisporites*, *Podocarpidites*, *Eucommiidites* are common. Angiosperms occur rarely, *Clavatipollenites*, *Perucipollis*, and small thick-walled psilate tricolpate and tricolporate as well as reticulate pollen grains, some Normapolles remains occur. Some marine microplankton, foraminifers and prasinophytes are present. This type of environment characterizes swampy sea-shore deposits.

Grey to black sandy claystones (44.80–43.20 m) alternate with thin layers of sandstone and contain rich angiosperm assemblage with periporate angiosperm pollen *Bohemiperiporis zaklinskae* Pacltová, thick-walled *Tricolpites barrandei* Pacltová, *Perucipollis minutus* Pacltová, *Tricolpites němejci* Pacltová, *Liliacidites*, *Brenneripollis* and morphologically more complicated forms of *Complexiopollis*. First well preserved *Complexiopollis* were found in 47.80 m. The occurrence of the immature angiosperms (found here in tetrads) is typical for the transgressive conditions. Gymnosperm pollen of *Taxodiaceaepollenites*, marine dinoflagellate cysts and common pteridophyte spores – *Osmundacidites*, *Gleicheniidites*, *Appendicisporites*, *Reticulatisporis* and bryophyte *Stereisporites* as well as some elateroid forms occur. This assemblage characterizes beginning of transgressive phase inside the marginal facies.

Black-coal (42,30–43 m) contain mainly spores of Lycopodiaceae *Camarozonosporites*, *Retitriletes*, Schizaeaceae – *Appendicisporites matesovae* (Bolchovitina) Norris, *A. tricuspidatus* Weyland et Greifeld, different species of *Cicatricosisporites*, thick-walled *Gleicheniidites*, of gymnosperm pollen *Taxodiaceaepollenites*, *Classopollis* and *Ephedripites*. Angiosperm pollen characterize *Clavatipollenites*, relatively large monolete reticulate pollen of *Liliacidites*, monocolpate pollen grains with broad reticulum reminding palms, small tricolpate forms, rare Normapolles and some non-marine plankton (*Chomotriletes minor* (Kedves) Pocock, *Ovoidites*). This assemblage characterizes the regressive phase.

Grey sandy claystones with black-coal fragments (39.70 –41.30 m) contain thick-walled reticulate angiosperm pollen *Tricolpites barrandei* Pacltová, periporate *Bohemiperiporis zaklinskae* Pacltová, different species of *Complexiopollis*, pteridophyte spores of Lycopodiaceae – *Camarozonosporites*, Gleicheniaceae – especially *Gleicheniidites carinatus* (Bolchovitina) Bolchovitina spores with broad interradial thickening. This part represents continuing transgressive phase.

The upper part of the borehole profile (47–39 m) was characterized by the frequent changes in transgressive--regressive phases, where new thick-walled angiosperm pollen appear. The assemblage suggests the mangrove vegetation. Some marine microplankton is present. The studied sediments were dated according to the Normapolles occurence as the upper part of the Peruc Member – *A. jukes-brownei* Zone (Pacltová 1977, Svobodová 1992a,b, Svobodová and Brenner 1999). Transitional zone between the Peruc and Korycany Member are characterized by higher

frequency of the sea-level fluctuations. The overlying layers (34–39 m) of the upper Cenomanian – *Calycoceras naviculare* and *Metoicoceras geslinianum* Zones were not sampled in the borehole Ln-1. Sea-level changes of the missing part were studied in the borehole Vrbno near Louny (Vl-1) which is situated close to Ln-1 as well as in the Pecínov quarry (Pacltová 1990, Uličný *et al.* 1997, Svobodová *et al.* 1998).

ŠTRAMBERK-KOTOUČ

Bryophyte, pteridophyte spores, gymnosperm and angiosperm pollen grains were recovered from the dark grey to black pelitic sediments in the Main quarry – Kotouč in Štramberk (Silesian unit, outer Western Carpathians) overlying the Tithonian-Lower Berriasian Štramberk limestone body. The Cretaceous rocks are preserved on the surface or penetrate into the karst cavities of the limestone and their age can differ. Most of the sediments are of the Lower Cretaceous age (Vavrdová 1981, Houša 1987, Svobodová 1998, a.o.). The youngest association of the late Albian-early Cenomanian age was found in one outcrop near the base of the Main quarry (eight level, sample 2/VIII). The palynospectra (Fig. 2) contain 47% dinocysts and acritarchs, 18% chitinous linings of foraminifers, 27% spores, 6% gymnosperm pollen and 3% angiosperm pollen. Spore and pollen assemblages deposited near the site of origin represent predominantly the local flora growing along the coastal margin and exhibit low species diversity. Pteridophyte spores are not very diversified, most specimens belong mainly to the Gleicheniaceae family – *Gleicheniidites senonicus* Ross, *Gleicheniidites saparicus* Juhász, *Clavifera triplex* (Bolchovitina) Bolchovitina, *Foveogleicheniidites* sp., Selaginellaceae, *Echinatisporis varispinosus* (Pocock) Srivastava and Schizaeaceae – *Klukisporites*, *Appendicisporites/Plicatella*, *Cicatricosisporites*. Pteridophytes from the family Gleicheniaceae represent a pioneer vegetation in a local swampy conditions. Gymnosperm pollen contain mostly bisaccates – *Podocarpidites*, *Phyllocladidites*, *Parvisaccites*, *Vitreisporites pallidus* (Reissinger) Nilsson. Spore and pollen assemblages deposited further offshore are generally more varied. It is the result of the admixture of inland and coastal forms brought by wind and water action. Bisaccate pollen are present nearly in all assemblages, but increase in relative percentage with distance offshore. Their dispersal is primarily by wind transport. Traverse and Ginsburg (1966) showed that their amount in surface sediments offshore from the Great Bahama Bank is often greater than in sediments deposited closer to the islands where the plants grow. Angiosperm pollen are firstly reported from Kotouč and consist of very small reticulate tricolpate forms *Retitricolpites* sp. and *Tricolpites minutus* (Brenner) Dettmann. Sporomorphs are very often corroded, caused by the filling of framboidal pyrite. Some scolecodonts and foraminiferal linings appear. This can suggest the environment with lower oxygen supply. Dinoflagellate cysts are very diversified and characterize the deeper part of the neritic sea – *Oligosphaeridium*, *Spiniferites*. Rare oceanic forms – *Pterodinium cingulatum* (Wetzel) Below appear (Skupien, pers. comm.). Stratigraphically significant occurences include the first appearance of *Palaeohystrichophora infusorioides* Deflandre and the last appearance of *Litosphaeridium siphoniphorum* (Cookson et Eisenack) Davey et Williams which indicate latest Albian to earliest Cenomanian (*S. dispar* Zone). Similar dinocyst assemblage was recorded from the uppermost part of the Lhoty Formation (late Albian) and lower part of the Godula Formation (late Cenomanian) of the Silesian unit (Skupien 1997, 1999).

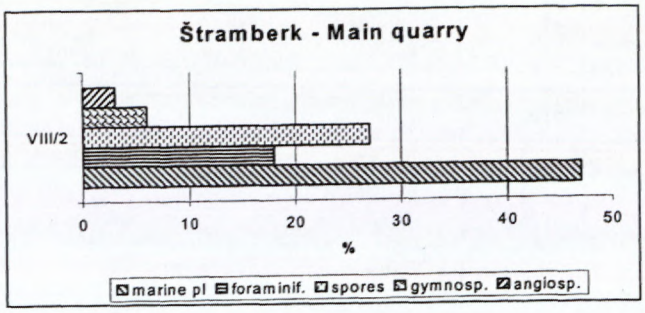


Fig. 2. Comparison of the relative abundance of group of palynomorphs in the section VIII/2, Štramberk quarry

CONCLUSIONS

The continuing transgression was characterized by sea-level changes in the uppermost part of the Peruc Member and especially in the transitional zone between the Peruc and Korycany Members. These fluctuations influenced palaeoecology and caused the changes of the composition of the vegetation. The studied profiles allowed to document the changes of the palynospectra according to the lithology and palaeoecology. Palynomorph assemblages include both terrestrial (spores and pollen, fungal spores etc.) and marine components (dinoflagellate cysts, acritarchs, chlorophycean and prasinophycean algae, foraminiferal test linings and scolecodonts). Generally, the terrestrial components in an assemblage decrease, and the marine components increase, with distance away from terrigenous influx (bisaccate pollen could be sometimes the exception). The occurrence and abundance of palynomorphs in sediments are controlled by their supply in the water and in the air above the water and by the sediment type. Post-depositional decay, oxidation and presence of pyrite may destroy a part or all of the palynomorph assemblage.

The palynospectra characterized fluvio-lacustrine, estuarine, marginal marine (Ledčice, Louny) and deeper neritic environment in Kotouč, Štramberk.

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Explanations to plates

All figures are x 1000, unless otherwise stated. Palynomorphs from plates 1, 2 are taken from borehole Kc-1 Ledčice, the Peruc Member. Palynomorphs from plate 3 are taken from borehole Ln-1 Louny, the Peruc Member. Palynomorphs from plate 4 are taken from outcrop in the Main quarry, VIII level, Štramberk.

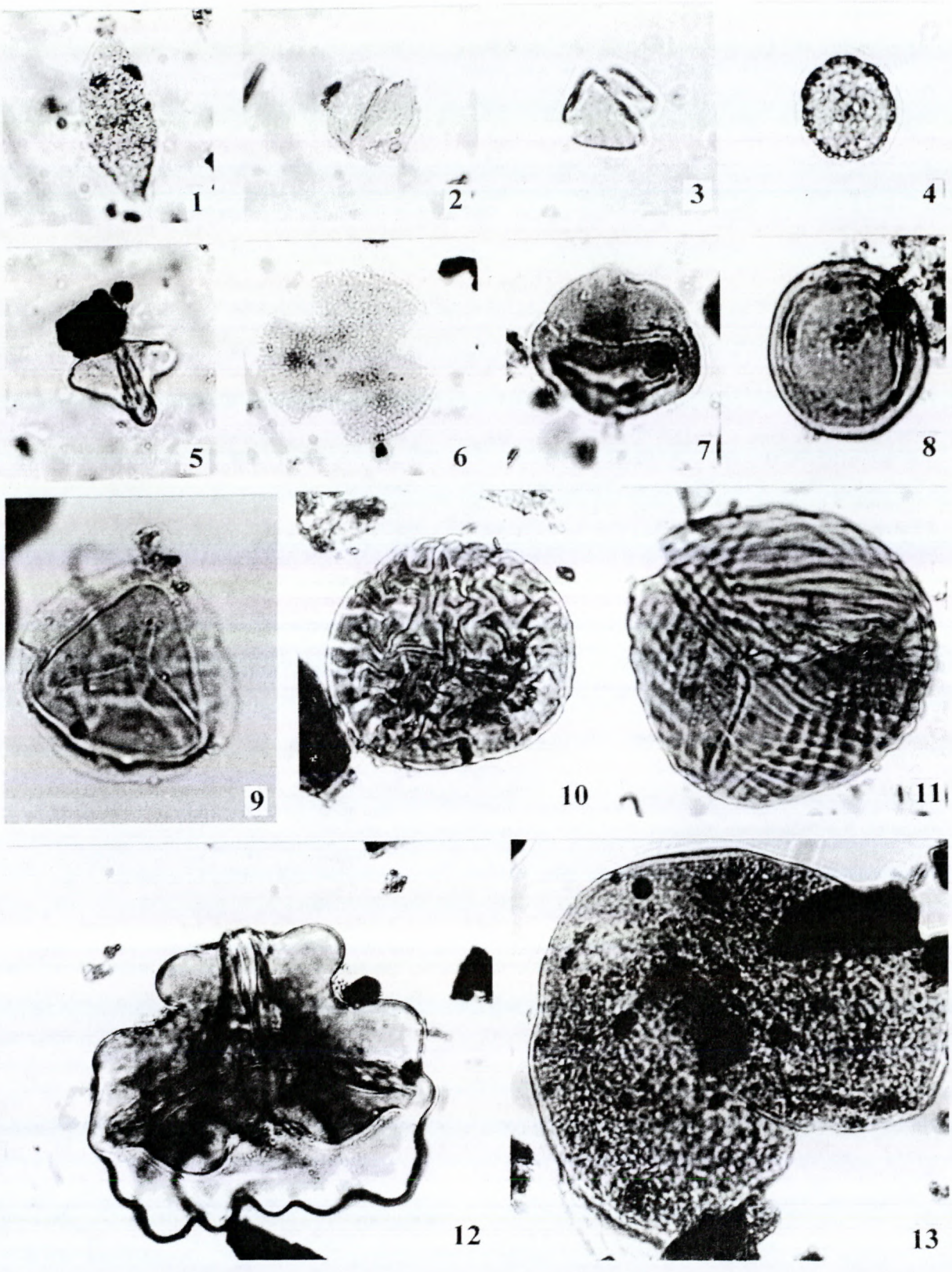


Plate 1

1 – *Liliacidites* sp., Kc-1, depth 90.8 m, upper claystones, estuarine environment,

2 – *Brenneripollis reticulatus* (Brenner) Juhász et Góczán, Kc-1, depth 90.8 m, upper claystones, estuarine environment,

3 – *Perucipollis minutus* Pacltová, Kc-1, depth 88.3 m, upper claystones, estuarine environment,

4 – *Bohemiperipollis zaklinskae* Pacltová, Kc-1, depth 106.5 m, lower claystones, fluvial environment,

5 – *Complexiopollis vulgaris* (Groot et Groot) Groot et Penny, Kc-1, depth 86.5 m, upper claystones, estuarine environment,

6 – *Retitricolpites amplifissus* Laing, Kc-1, depth 108.5 m, lower claystones, fluvial environment,

7, 8 – *Classopollis classoides* (Pflug) Pocock et Jansonius (7 – equatorial view, 8 – polar view), Kc-1, depth 90.8 m, upper claystones, estuarine environment,

9 – *Retitriletes austroclavatidites* (Cookson) Döring, Krutzsch, Mai et Schulz, Kc-1, depth 106.5 m, lower claystones, fluvial environment,

10 – *Camarozonosporites insignis* Norris, Kc-1, depth 88.3 m, upper claystones, upland vegetation in estuarine environment,

11 – *Cicatricosisporites* cf. *potomacensis* Brenner, Kc-1, depth 109.5, lower claystones, fluvial environment,

12 – *Gleicheniidites carinatus* (Bolchovitina) Bolchovitina, Kc-1, depth 109.5 m, lower claystones, upland vegetation in alluvial plain,

13 – *Parvisaccites radiatus* Couper, Kc-1, depth 108.5 m, lower claystones, fluvial environment.

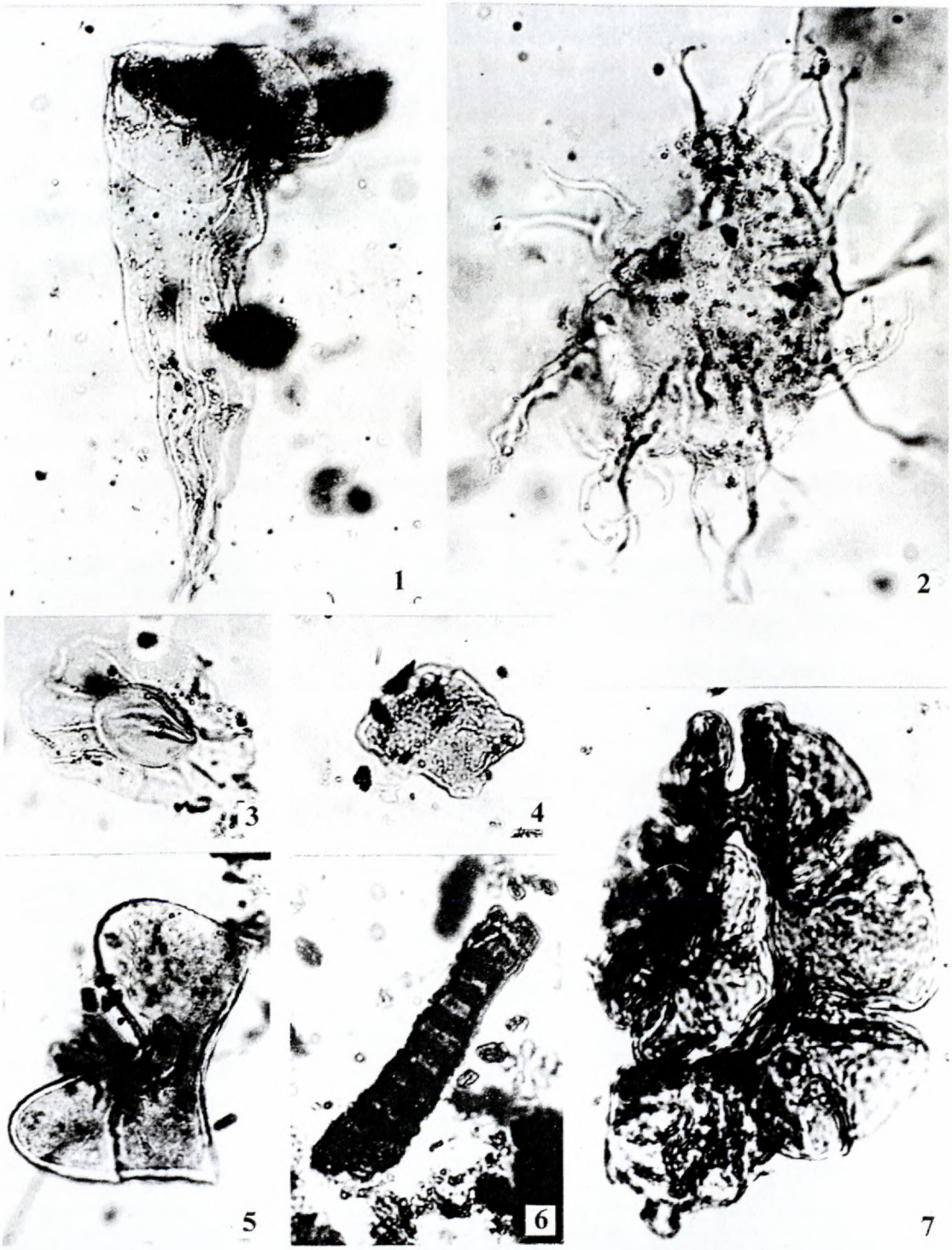


Plate 2

1 – *Odontochitina operculata* (O. Wetzel) Deflandre et Cookson, Kc-1, depth 96.5 m, upper claystones, deltaic conditions,
2 – *Surculosphaeridium ?longifurcatum* (Firtion) Davey *et al.*, Kc-1, depth 86.5 m, upper claystones, estuarine conditions – tidal flat,
3 – *Pterospermella australiensis* (Deflandre et Cookson) Eisenack, Kc-1, depth 88.3 m, upper claystones, estuarine conditions – tidal flat,
4 – *Tetraporina* sp., Kc-1, depth 104.6 m, lower claystones, lake, x 500,
5 – *Schizocystia* sp., Kc-1, depth 104.6 m, lower claystones, lake,
6 – *Pluricellaesporites psilatus* Clarke, hyphae of Fungi imperfecti, Kc-1, depth 96.5 m, estuarine conditions,
7 – Foraminifera linings, Kc-1, depth 88.3 m, upper claystones, estuarine conditions – tidal flat.

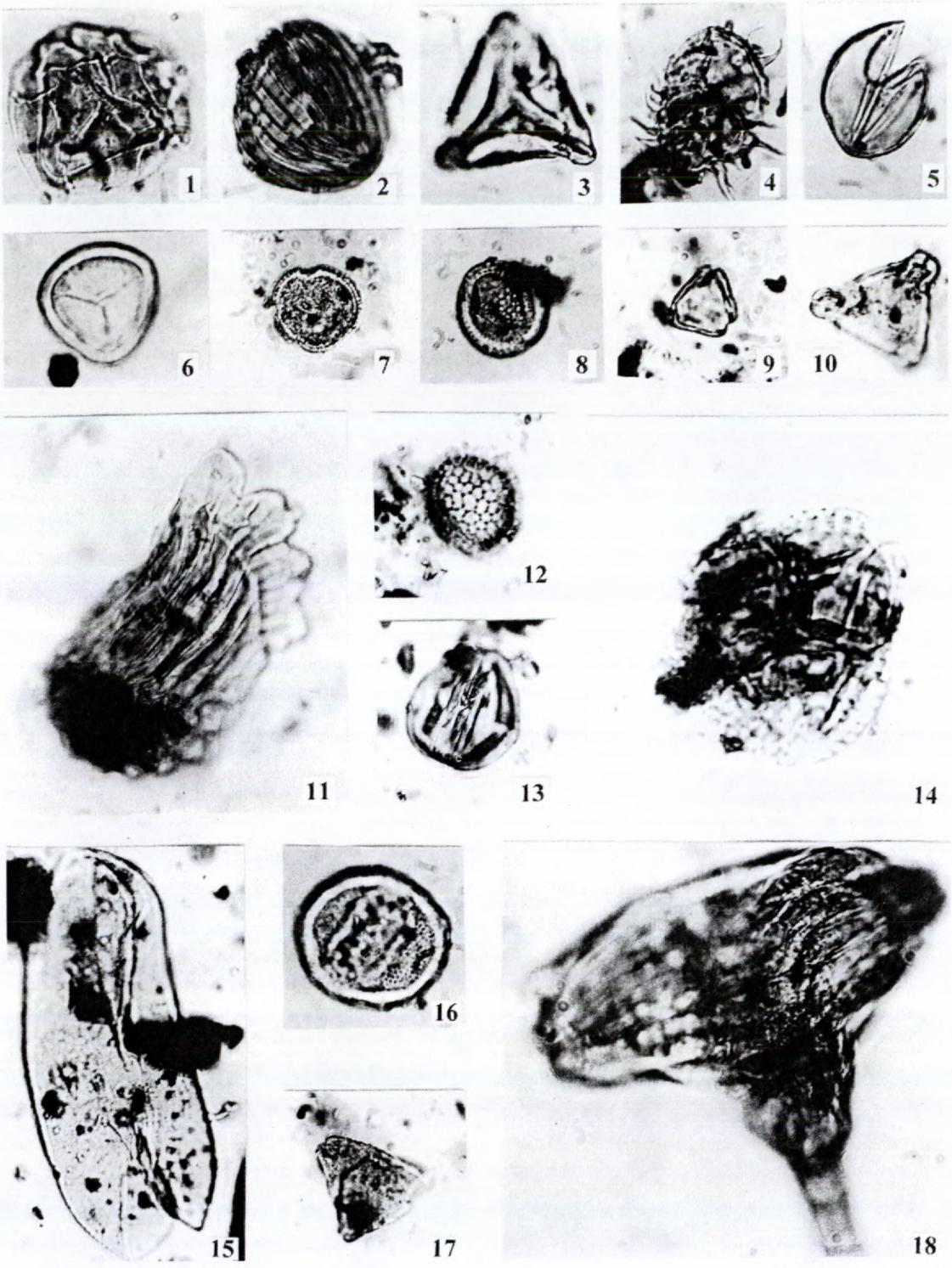


Plate 3

1 – *Retitriletes austroclavatidites* (Cookson) Döring, Krutzsch, Mai, Schulz, Ln-1, depth 42.3 m, regressive phase,
2 – *Cicatricosisporites* sp., Ln-1, depth 55.8 m, transgressive phase, marginal facies,
3 – *Gleicheniidites* sp., Ln-1, depth 47.8 m, mangrove vegetation,
4 – *Echinatisporis varispinosus* (Pocock) Srivastava, Ln-1, depth 60.05 m, swampy marginal facies,
5 – *Taxodiaceaepollenites hiatus* (Potonié) Kremp, Ln-1, depth 44.5 m, marginal facies,
6 – *Stereisporites psilatus* (Ross) Pflug, Ln-1, depth 4.8 m, marginal facies,
7 – *Bohemiperipollis zaklinskae* Pacltová, Ln-1, depth 44.5 m, marginal facies,
8 – *Tricolpites barrandei* Pacltová, Ln-1, depth 40.75 m, mangrove vegetation,
9 – *Perucipollis minutus* Pacltová, Ln-1, depth 44.5 m, marginal facies,
10 – *Complexiopollis* Type M, Ln-1, depth 47.8 m, mangrove vegetation,
11 – *Appendicisporites matesovae* (Bolchovitina) Bolchovitina, Ln-1, depth 41.0 m, mangrove vegetation,
12 – *Brenneripollis reticulatus* (Brenner) Juhász et Góczán, Ln-1, depth 44.5 m, marginal facies,
13 – *Tricolporoidites minimus* Pacltová, Ln-1, depth 43.5 m, transgressive phase in marginal facies,
14 – *Ajatipollis* sp. (pollen tetrad), Ln-1, depth 60.6 m, swampy marginal facies,
15 – *Ovoidites parvus* (Cookson et Dettmann) Nakoman, Ln-1, depth 53.2 m, regressive phase,
16 – *Clavatipollenites minutus* Brenner, Ln-1, depth 42.3 m, regressive phase,
17 – *Complexiopollis* sp., Ln-1, depth 47.8 m, mangrove vegetation,
18 – *Appendicisporites tricuspidatus* Weyland et Greifeld, Ln-1, depth 42.9 m, regressive phase.

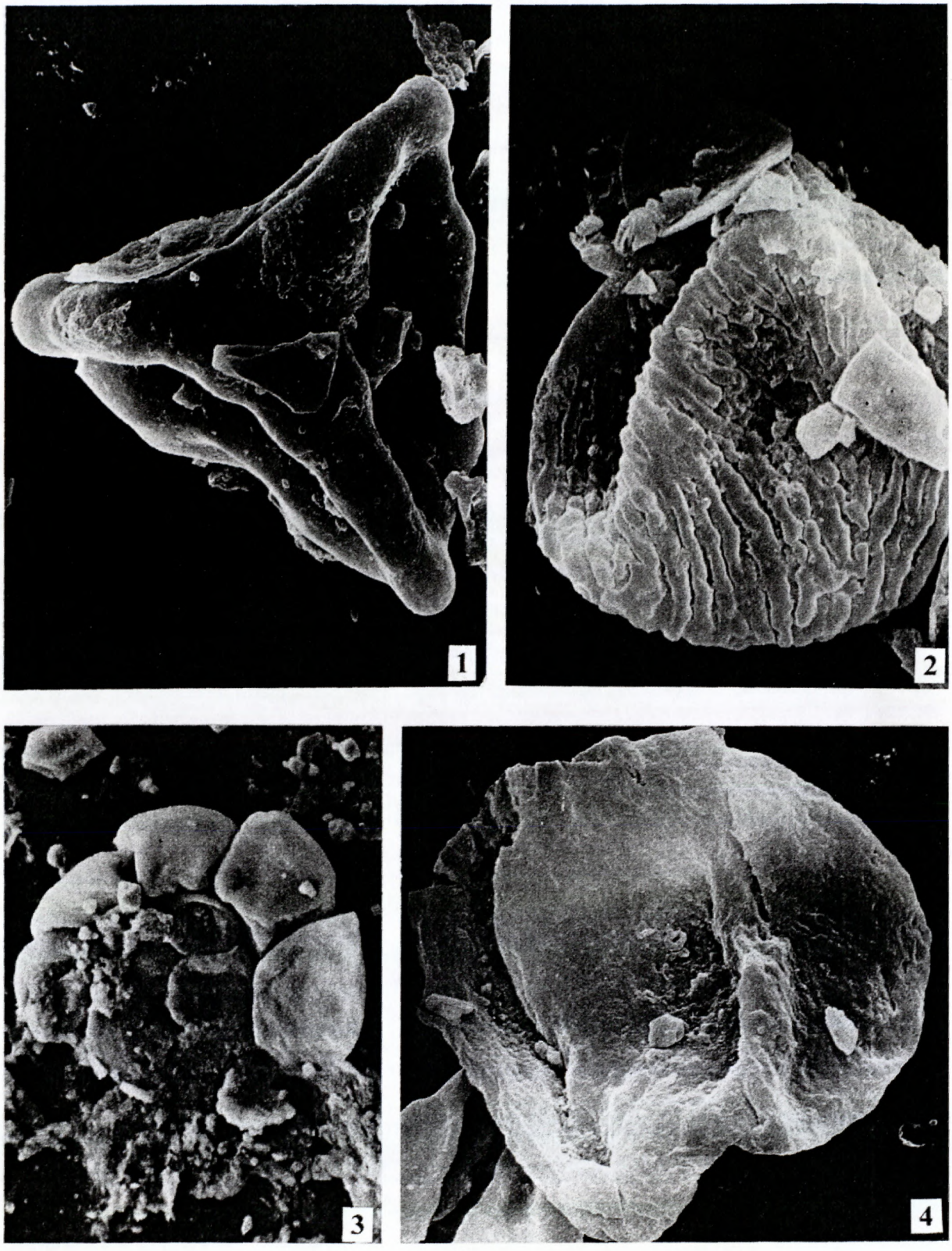


Plate 4

1 – *Clavifera triplex* (Bolchovitina) Bolchovitina, Štramberk, Main quarry, 2/VIII, marine environment, SEM, x 2000,
2 – *Cicatricosisporites* sp., Štramberk, Main quarry, 2/VIII, marine environment, SEM, x 2000,
3 – Foraminifera linings, Štramberk, Main quarry, 2/VIII, marine environment, SEM, x 1200,
4 – Parvisa*ccites radiatus* Couper, Štramberk, Main quarry, 2/VIII, marine environment, SEM, x 1200.

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DISCINITES CF. *JONGMANSII* HIRMER FROM THE CARBONIFEROUS OF THE INTRASUDETIC BASIN (CZECH REPUBLIC)

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Abstract: Newly found specimen is the first occurrence of the genus *Discinites* in the Intrasudetic Basin. The sporophyll is disc-like with dentate margin by which this specimen differs from all Central and Western Bohemian *Discinites*. The specimen from the Intrasudetic Basin comes from the Prkenný Důl-Žďárky Member, Žacléř Formation of Upper Duckmtian strata. It is older than specimens found in Central and Western Bohemian Upper Palaeozoic basins of Bolsovian age. Specimens from the Intrasudetic Basin resemble very much to Hirmer's *Discinites jongmansii*. *Rhacopteris busseana* from the same age strata of the Intrasudetic Basin could be regarded as a mother plant of *Discinites jongmansii*.

INTRODUCTION

Discinites was first described by Feistmantel (1879), based on specimen from Central Bohemia. Later, Němejc (1937, 1941) described additional 3 species of *Discinites* in the Central and Western Upper Palaeozoic Bohemian basins. However, no specimen of *Discinites* was known in the Intrasudetic basin before this paper.

MATERIAL AND METHODS

The specimen described here was collected on the spoil pile of the Nejedlý Mine (formerly Ida gallery) at Rtyně v Podkrkonoší (Fig. 1), Intrasudetic Basin. It is preserved as a compression and impression counterpart in grey mudstone coming from the Strážkovice Group of coals, Prkenný Důl-Žďárky Member, Žacléř Formation corresponding to the Upper Duckmantian strata. Even though coals of two units (Prkenný Důl-Žďárky and Svatoňovice members) had been mined at the Ida gallery, the plant assemblage of the slab proved the Duckmantian age (*Lepidodendron acutum* Sternberg, *Annularia radiata* (Brongniart) Sternberg, *Sphenophyllum cuneifolium* Sternberg and *Pecopteris aspidioides* Sternberg). The Cantabrian Svatoňovice Member had been exploited till the beginning of the 80ˢ, whereas the specimen of *Discinites* cf. *jongmansii* had been found in 1989. It is stored in collections of the Czech Geological Survey, Prague under No: ZŠ-77a–b.

Surface of the sporophyll has been observed using the binocular microscope Nicon. The rough epidermal structure is visible (Pl. 1, fig. 4), however the preservation of the specimen does not allow any detail microscopic studies.

SYSTEMATICS

Division Progymnospermophyta Beck 1960
Class Noeggerathiopsida Zimmermann 1959
Order Noeggerathiales Němejc 1931
Family Discinitaceae Remy et Remy 1977

Morpho-genus *Discinites* K. Feistmantel 1879 emend. Zhifeng et Thomas 1995
Type: *Discinites bohemicus* K. Feistmantel 1879

Discinites cf. *jongmansii* Hirmer 1940
Pl. 1, figs. 1–8

Compare:
1940 *Discinites jongmansi* nov. spec.; Hirmer, p. 30–32, pl. C/D, figs. 1–10.
1941 *Discinites jongmansi* Hirmer; Hirmer, p. 146, fig. 5 a–c.
1964 *Discinites jongmansi* Hirmer; Boureau, p. 501–502.

Holotype: Hirmer (1940), pl. C/D, fig. 1, 1a. Collections Geologisch Bureau vor hèt Mijngebied te Heerlen, Limburg, Netherlands, No: 3682.



Fig. 1. Map of the Czech Republic. Black square indicates the locality of *Discinites* cf. *jongmansii* (Rtyně v Podkrkonoší).

Locality: Limburg Basin, Maurits Mine, Limburg, Netherlands.

Stratigraphic horizon: Upper part of the Hendrik Group (Formation), upper part of the Lower Duckmantian (Westphalian (B), Carboniferous).

Diagnosis (according to Hirmer 1940): Cone fragments up to 95 mm long and 18 mm wide. Axis 4 mm wide. The sporophylls are circular and flat. Sporophyll is covered by sporangia 2 mm in diameter. Sporophyll distal upturned part is undivided in 2 or 3 mm length and then divided apically into relatively wide teeth, 6–7 mm long and 2.5–3 mm wide.

Description of the Bohemian specimen. The sporophyll is disc-like. Unfortunately, it is not complete. The distance between axis and sporophyll margin is 10–11 mm. The axis has 3 or 4 mm in diameter. Entire sporophyll had probably 24 or 25 mm in diameter. The distal parts of the sporophyll is turned upwards becomming parallel to the axis and is divided apically into long teeth. The undivided upturned portion is about 3 mm long, but it is preserved only in a half of the sporophyll. The teeth are about 8 mm long. There are about 30 teeth on the sporophyll (the specimen beers only two teeth preserved) and their basal width is about 1 mm. Neither sporangia nor scars have been observed. Probably only abaxial surface of the sporophyll without sporangia was observed. The cells of abaxial surface are radially oriented, the shape of cells is approximately longitudinally tetragonal (pl. 1, figs. 4 and 5). The cells are 100–250 μm long and 20–50 μm wide.

Comparison: Comparison of *Discinites* with related genera (*Lacoea* Read, *Noeggerathiaestrobus* Feistmantel, *Saarodiscites* Hirmer, *Heninia* Stockmans et Willière, *Tongshania* Stockmans et Mathieu) have been published by Zhinfeng and Thomas (1995).

The above described specimen is the most similar to the specimens of *Discinites jongmansii* figured by Hirmer (1940). The sporophyll is disc-like, flat. There is prominent difference between proximal fertile part and distal sterile dentate part turned up parallel to the cone axis. The "disc" is not always circular, therefore two values are mentioned in table 1.

Table 1 Comparison of some measured values from Bohemian and Dutch specimens of *Discinites jongmansii* Hirmer.

Reference	Diameter of proximal part of sporophyll (mm)		Entire sporophyll diameter (mm)
	The largest	The smalest	
This paper	18	16	?24–25
Hirmer (1940) – holotype	23	20	27
Hirmer (1940) – pl. C/D, fig. 5	18	17	?
Hirmer (1940) – pl. C/D, fig. 2	23	22	26
Hirmer (1940) – pl. C/D, fig. 6	17	16	?
Hirmer (1940) – pl. C/D, fig. 7	17	15	?

From the values in table 1 it is evident that Bohemian specimen falls within the variability of the species *Discinites jongmansii*. The only difference is in the form of teeth. The Bohemian specimen has slender teeth up to 8 mm long and 1 mm wide, whereas Hirmer's specimens have robust teeth 6–7 mm long and 2.5–3 mm wide. This feature of Bohemian specimen does not fall within the diagnosis of *Discinites jongmansii*. The Bohemian specimen can extend the variability of *Discinites jongmansii* or it represents a geographical variety of this species.

Discinites cf. *jongmansii* differs from all Central and Western Bohemian Carboniferous *Discinites* (Němejc 1937, 1941, Bek and Šimůnek 2005). These *Discinites* have not preserved dentate sporophyll margin. Only *Discinites bohemicus* Feistmantel from Central Bohemian Region has very small teeth 1 mm long and wide.

Another very similar species is *Discinites dentilongus* Zhifeng et Thomas from the Lower Permian of China. However, it differs by long teeth up to 13 mm long, stratigraphical and geographical distribution of this species is also quite different.

BOTANICAL AFFINITY

Rhacopteris busseana Stur, 1885 is considered as a mother plant of *Discinites* cf. *jongmansii*. This is deduced from the common occurrences of remains *Discinites* (cf.) *jongmansii* and *Rhacopteris busseana*. Rhacopterid species are extremely rare in the Intrasudetic Basin. Only one species *Rhacopteris busseana* is known from here (Němejc 1958, 1963). This species is also referred from corresponding strata of the Limburg Basin (Jongmans and Dijkstra 1963), where *Discinites jongmansii* was described from. The age of strata with findings of *Rhacopteris busseana* and *Discinites jongmansii* in both regions is similar – the Duckmantian.

Rhacopteris busseana Stur 1885
Pl. 1, fig. 9

1885 *Rhacopteris busseana*; Stur, p. 7, pl. 62, figs, 1 and 2.
1928 *Rhacopteris asplenites* Gutbier; Němejc, p. 69–72, pl. 3, fig. 4, (?1–3).
1940 *Rhacopteris busseana* Stur; Guthörl, p. 56–58, pl. 12/13, figs. 1–3, Text-pl. G/H, figs. 1–3, Text-pl. J, text-figs 11a–11c.
(Extensive synonymy was published in Jongmans and Dijkstra, 1963, p. 2844–2845).

Holotype: Stur (1985), pl. 62, fig. 1. Collection of "Geologisches Bundesanstalt Wien", Vienna, Austria.

Locality: Intrasudetic Basin, Žďárky near Hronov, Wilhelmina Mine.

Stratigraphic horizon: Prkenný Důl-Žďárky Member, Žacléř Formation, Upper Duckmantian, Westphalian (B), Carboniferous.

Diagnosis: Pinnate frond, 40–50 cm long, rachis 6 mm wide, pinnules alternate in two rows in distances about 25 mm one from another. Pinnules are up to 60 mm long and 18 mm wide. The whole pinnule is deeply divided into narrow dentate lobes up to the centre of the pinnule. Acroscopic basal lobe is deeply cut and divided into two parts. It protrude distinct from other lobes. The venation is dichotomous several times, the veins ends in small teeth in the top of lobes. The midvein is not prominent.

Remark: The specimen described by Němejc (1928, pl. 3, fig. 4, herein pl. I, fig. 9) comes from the same locality as the holotype. It was originally described as *Rhacopteris*

asplenites Gutbier and later transfered to *Rhacopteris busseana* Stur by Guthörl (1940).

Conclusion: The specimen found in the Intrasudetic Basin probably belongs to *Discinites jongmansii* Hirmer. It differs from the typical material only by slender and longer teeth.

The mother plant of *Discinites jongmansii* is most probably *Rhacopteris busseana* Stur. This plant occurs in both regions of distribution *Discinites jongmansii*. It is the only rhacopterid known from the Intrasudetic Basin.

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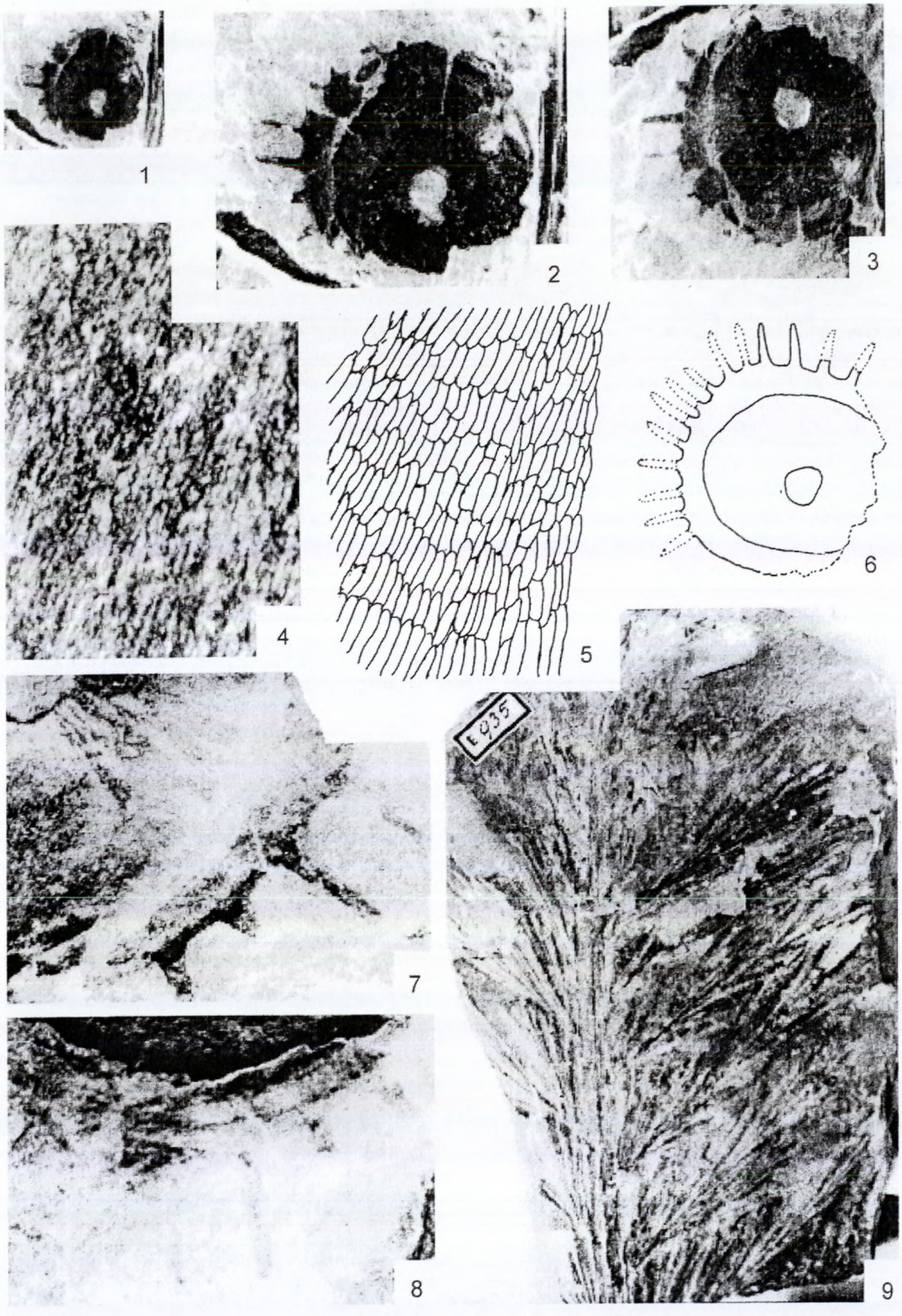
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1–8 – *Discinites* cf. *jongmansii* Hirmer, Loc. Rtyně v Podkrkonoší, Nejedký mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Duckmantian (Westphalian B), coll. Czech Geological Survey, Prague.
1– Disc-like sporophyl with dentate margin, No. ZŠ-77a, 1,
2 – Detail of fig. 1, 2,
3 – Counterpart of fig 1, No. ZŠ-77b, 2,
4 – Detail of abaxial surface of the sporophyll with cell structure, 40,
5 – Drawing of fig. 4, 40,
6 – Drawing of disc-like sporophyll from fig. 3, 2,
7, 8 – Details of sporophyll margin with teeth. Both 5,
9 – *Rhacopteris busseana* Stur. A fragment of the frond. Specimen figured previously by Němejc (1928, pl. 3, fig. 4) under the name *Rhacopteris asplenites* Gutbier. Loc. Žďárky near Hronov, Wilhelmina mine. The basin and stratigraphy the same as figs 1–8. Coll. National Museum of Prague, No. E 935, 1.

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TERTIARY FLORA AND VEGETATION OF THE LOCALITY PŘÍVLAKY NEAR ŽATEC (MOST BASIN)

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Abstract: The flora of Přívlaky is bound to silty claystones to sandy siltstones, which occur in downcuting of the Ohře River. It includes 22 taxa of angiosperms – dicots. Vegetation can be interpreted as a relatively temperate riparian forest with dominance of deciduous elements on humid habitats. The flora of Přívlaky is correlated with the Upper Oligocene floristic assemblage Thierbach (in the sense of Mai and Walther 1991) or with floristic assemblage Linz–Krumvíř of the Upper Oligocene – Lowest Miocene (Kvaček and Walther 2001) on the basis of occurrences of *Fagus saxonica* Kvaček et Walther. Therefore it can be supposed that the deposits from the locality Přívlaky represent isolated remnants of erosion processes, which could be connected to the Tertiary river system or its equivalent delta sediments. For new interpretation see Teodoridis (2004).

INTRODUCTION

First paleobotanical research was given by Konrádová (1959) from the locality Přívlaky. Z. Kvaček (personal communication) determined some of the leaf material as *Fagus saxonica* Kvaček et Walther from this area, which was collected originally by the former curator of the Litvínov Museum, M. Sládek in 1983. Z. Kvaček's team during 1998–1999, collected further material. I began to be interested in this problematic due to the mentioned occurrences of *Fagus saxonica* and a prevailing opinion that these sediments belong to the Overlying complex of the Most Formation – Early Miocene (e.g., Malecha 1962, Václ and Malkovský 1962). But it does not stratigraphically correspond, because *Fagus saxonica* has been known as a typical representative of Upper Oligocene floristic associations, e.g., Thierbach (Mai and Walther 1991) or Kleinsaubernitz near Bautzen (Walther 1999).

GEOLOGICAL SETTING

The locality Přívlaky is situated in the area of Žatec, about 4.5 km northwest from Žatec and 3.7 km southeast from the dam-wall of the Nechranice Dam (Fig. 1). Individual plant occurrences of the locality Přívlaky were found in the old sandpit (about 250 m from chapel) and on sedimentary outcrops in downcutting of the river Ohře (outcrops above the village of Přívlaky). Sediments are monotonic, mainly silty claystones to sandy siltstones, which are grey and yellowish in colour. Setting of sediments can be interpreted as distal crevasse splays according to occasionally allochthonous accumulations of plant fragments in one place and time (detailed sedimentological study in preparation).

CHARACTER AND PRESERVATION OF MATERIAL

All individual leaf impressions were determined only on the basis of morphological features due to poor preservation, which prevented to use epidermal analyse of taxa. The plant material is mostly fragmented or rarely complete, which is typical of fluviatile setting with allochthonous taphocenoses. The investigated material is housed in palaeobotanical collections of the Faculty of Science, Charles University in Prague (sign. PŘ) and in the Regional Museum at Most (sign. G/pa).

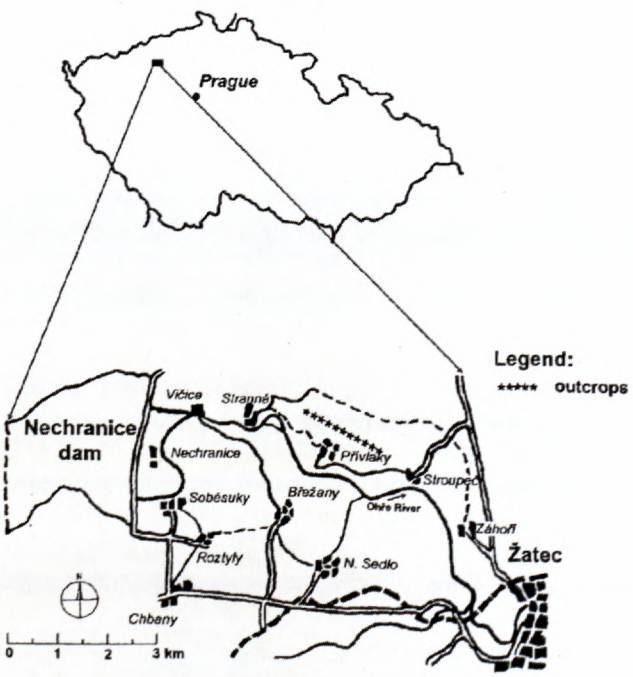


Fig. 1. Location of Přívlaky.

Systematic part

Hamamelidaceae

Genus *Liquidambar* L.
Liquidambar europaea Al. Braun in Buckland 1836
Pl. 2, fig. 8, Fig. 2.3
1836 *Liquidambar europaeum* Al. Br.; Braun in Buckland, p. 513.
1869 *Acer rueminianum* Heer; Ettingshausen partim, p. 23, pl. 48, fig. 8, non fig. 9.

Material: 5 incomplete leaves (impressions).

Description: Leaves palmately 3 to 5- lobed, 33 to 56 mm long, 50 to 60 mm broad, lobes oblong to triangular, base shallowly cordate to cordate, apices acute, sinuses round, open, margin regularly crenulate; venation basal actinodromous, 3 to 5 primary veins strong, originating at 52 to 72°; secondary veins looping, venation of higher order poorly preserved.

Remarks: The determination and assigning of the material to *Liquidambar europaea* Al. Br. is based on the morphology of leaves (mainly the whole form of the leaf, venation and crenulate margin). This material is possible to compare to the leaf impressions from other localities of the Most Basin – e.g., Březánky, Zabrušany (Ettingshausen 1866, 1869, Kvaček and Hurník 2000) or Čermníky (Bůžek 1971).

Genus *Fothergilla* L. vel *Parrotia* C. A. Mey vel *Shaniodendron* Deng, Wei et Wang

Parrotia pristina (Ettingshausen 1851) Stur 1867 sensu Bůžek 1971
Pl. 2, fig. 4, pl. 3, fig. 7, Fig. 2.9

1851 *Styrax pristinum* Ettingshausen; p. 19, pl. 3, fig. 9.
1867 *Parrotia pristina* (Ett.) Stur; p. 4, pl. 40, figs. 24, 25.
1971 *Parrotia pristina* (Ett.) Stur; Bůžek, p. 52, pl. 16, figs. 8–12, pl. 17, figs. 1–11, text-fig. 4.

Material: 2 complete leaves and 4 fragments (impressions).

Description: Leaves broadly elliptic to ovate, 21 to 76 mm long, 22 to 43 mm broad (maximum in the upper third of their length), apex acute, base rounded with fragmentary petiole (2 to 7 mm long), margin in upper part distinctly undulate, basal part slightly undulate or entire; venation simple craspedodromous, midrib strong, straight or curved, secondary veins straight or curved upward, alternate, originating at acute angles, basal pair distinct and opposite, tertiary veins often straight or forked, venation of higher orders poorly preserved.

Remarks: The material described above is assigned to *Parrotia pristina* (Ett.) Stur sensu Bůžek (1971). The determination is based on morphological features (i.e., leaf form, type of the margin, course of the basal pair of secondary veins) and comparison to abundant material from the Pětipsy area (Bůžek 1971). It is very problematic to safely solve the affinity of this species to the genera *Fothergilla* L., *Parrotia* C. A. Mey. or *Shaniodendron* Deng, Wei et Wang. A statistical analysis attempts to show differentiation of *Parrotia*, *Fothergilla* and *Shaniodendron* (e.g., Bůžek 1971, Wang and Li 2000). Due to rare occurrences in the locality Přívlaky it is not possible to safely recognise affinity to the mentioned genera. Therefore I use a collective Bůžek's name *Parrotia pristina* (Ett.) Stur, before the taxonomy is definitely solved.

Fagaceae

Genus *Fagus* L.

Fagus saxonica Z. Kvaček et Walther 1991
Pl. 2, figs. 1, 3, Fig. 2.8

1847 *Fagus deucalionis* Unger; p 101, pro parte, pl. 72, figs. 5, 6.
1989a *Fagus attenuata* Goeppert ssp. *seussensis* Knobloch; Bůžek and Kvaček, p. 22–24.
1989b *Fagus attenuata* Goeppert ssp. *seussensis* Knobloch; Bůžek and Kvaček, p. 17–18.
1991 *Fagus saxonica* sp. nov.; Z. Kvaček et Walther, p. 56, pl. 30, figs. 1-8, text-figs. 3.1–10.

Material: 18 complete and incomplete leaves

Description: Leaves narrow elliptic to ovate, 54 to 95 mm long, 24 to 35 mm broad, apex acute, base symmetric, rare asymmetric (G/pa 214-1), widely cuneate to rounded, rarely with a fragmentary petiole (5 to 8 mm long), margin regularly simple serrate with acute, triangular teeth; venation simple craspedodromous, midrib strong, often straight, rarely zik-zak; secondary veins straight, curved admedially, innervating teeth apices, alternate, in 10 to 16 pairs, originating at 40 to 55°, venation of higher order poorly preserved.

Remarks: The material is assigned to *Fagus saxonica* Z. Kvaček et Walther (Kvaček and Walther 1991) on the basis of leaf morphological features, i.e., the form and the size of leaves, the character of the margin and the number of secondary vein pairs. Similar large and narrow leaves were described by Němejc (1949) as *Fagus silvatica* L. from localities Na Bendovce /Sv. Antonín/ near Rakovník (Teodoridis 2001) and by Kvaček and Bůžek (1989a, b) as *Fagus attenuata* Goepp. ssp. *seussensis* Knobloch from the localities Želeč and Nesuchyně. Occurrences of this taxon have been also known from the tuffitic ironstones at Počerny and Podlesí near Karlovy Vary (see Holý 1984, Kvaček *et al.* 1989).

Betulaceae

Genus *Betula* L.

Betula sp.
Pl. 1, fig. 2, Fig. 2.23

1851 *Betula prisca* Ettingshausen; p. 11, pl. 1, figs. 15–17.
1855 *Betula subpubescens;* Goeppert, p. 11, pl. 3, fig. 9.
1949 *Betula prisca* Ett.; Němejc, p. 42, pl. 3, figs. 3–6, pl. 11, figs. 2–12, pl. 12, figs. 1–5.
1949 *Betula subpubescens* Goepp.; Němejc, p. 42, pl. 3, fig. 7, pl. 9, figs. 3, 3a.

Material: 10 incomplete leaves and fragments (impressions).

Description: Leaves elliptic to ovate, 32 to 69 mm long and 15 to 43 mm broad, base broadly cuneate or rounded, with a fragmentary petiole (3 mm long), apex acute, margin entire at leaf base, upwards irregularly double-serrate; venation simple craspedodromous, midrib strong, moderate, often straight, rarely curved, secondary veins thin, distinct, alternate or opposite, in 7 to 8 (10) pairs, interspaced at distances of 4 to 7 mm, originating at 40 to 50°, slightly curved, tertiary often straight or forked, innervating apices of secondary teeth, venation of higher orders poorly preserved.

Remarks: The material is possible to assign to *Betula* sp. on the basis of leaf morphology. The determination of this taxon and other taxa from the family *Betulaceae* is very problematic for large morphological variability of leaves and for the lack of epidermal structure. The impressions from Přívlaky are very similar to the material, which was described under the same name from the localities of the "Hlavačov gravel and sand", the Pětipsy area and from Holedeč. This material is also similar to the leaves, which were described as *Betula prisca* Ett. by Ettingshausen (1851). This name is no more in use for its misapplied original diagnosis (see in detail Hummel 1991). Hummel (1991) compared these leaves (*Betula prisca* Ett.) to the material, which Goeppert (1855) assigned to *Betula subpubescens* Goepp.

Genus *Alnus* B. Ehrh.

Alnus sp. sensu Bůžek 1971
Pl. 1, figs. 1, 3, 7, Figs. 2.4, 19, 24

1845 *Alnus kefersteinii* (Goepp.) Unger; Unger partim, p. 115, pl. 33, fig. 4.
1866 *Alnus kefersteinii* (Goepp.) Ung.; Ettingshausen, p. 47, pl. 14, figs. 19, 20 (strobili figs. 17, 18).
1866 *Betula grandifolia* Ett.; Ettingshausen, p. 47, pl. 14, figs. 23, 24.
1891 *Alnus kefersteinii* (Goepp.) Ung.; Engelhardt, p. 156, pl. 7, figs. 25, 26.
1971 *Alnus* sp.; Bůžek, p. 48–49, pl. 13, fig. 12, pl. 15, figs. 1–6.

Material: 20 incomplete leaves and fragments (impressions).

Description: Leaves elliptic to ovate, 35 to 92 mm long and 22 to 50 mm broad, base broadly cuneate or rounded to slightly cordate, apex acute; margin entire in basal part, upwards irregularly double-serrate; venation simple craspedodromous, midrib strong, moderate, straight, secondary veins thin, distinct, alternate or opposite (often at basal part), in 9 to 11 pairs, interspaced at distances of 7 to 14 mm, curved towards to apex and margin, originating at 40 to 65°, Tertiary veins straight or forked, venation of higher orders poorly preserved.

Remarks: The leaf material from Přívlaky can be assigned to *Alnus* sp. sensu Bůžek 1971 similarly to the material from the "Hlavačov gravel and sand" and from the Pětipsy area. This taxon is based on characteristic morphological features i.e., broader leaves, markedly broadly cuneate or rounded to slightly cordate base, higher number of secondary vein pairs and larger interspaces. The two latter mentioned features are significant for distinguishing of *Betula* sp. (above-described). The impressions described above have many typical morphological parameters, which are not identical to those of far known fossil species of *Alnus* B. Ehrh., e.g., *Alnus menzelii* Raniecka-Bobrowska 1954, *Alnus rotundata* Goepp. (Němejc 1949), *Alnus rostaniana* Saporta emend. Mai et Walther 1991. Besides, I am aware of large leaf morphological variability of this genus. Therefore, I do not determine the material to the species without cuticular analysis.

Myricaceae

Genus *Myrica* L.

cf. *Myrica* sp.
Pl. 2, fig. 7, Fig. 2.16

Material: Only 1 leaf fragment (impression).

Description: Leaf elliptic, 59 mm long and 14 mm broad, base not preserved, apex acute; margin simple-serrate with triangular teeth; venation simple craspedodromous, midrib distinct, strong, moderate; secondary veins alternate, numerous, originating at 35 to 50°; venation of higher orders poorly preserved.

Remarks: The fragment is assigned only to the genus level as cf. *Myrica* sp. due to lack of epidermal analysis. Main morphological features for determination are leaf form, character of margin and simple craspedodromous type of venation. The latter feature is important for differentiation of the genus *Salix* L.

Genus *Comptonia* L' Hérit. in Aiton

Comptonia difformis (Sternberg 1825) Berry 1906
Pl. 1, figs. 6, 8, Fig. 2.15

1821 *Asplenium diforme* Sternberg; p. 33, pl. 24, fig. 1. nom. illegit.
1825 *Aspleniopteris difformis* Sternberg; p. 33, pl. 24, fig. 1.
1828 *Comptonia acutiloba* Brongniart; p. 141, 143, 209.
1906 *Comptonia diformis* (Sternb.) Berry; p. 495.

Material: 13 identifiable fragments (impressions).

Description: Leaves of different size, pinnately lobed, oblong to lanceolate in outline, apex and base not preserved, lobes of different size, ovate, alternate or opposite, apex acute; margin entire; venation eucamptodromous, midrib strong, moderate, secondary veins thin, 2 to 4 veins innervating one lobe, originating at 80 to 90°, tertiary veins often straight or forked, creating a reticular pattern; venation of higher orders poorly preserved.

Remarks: This material can be assigned to *Comptonia difformis* (Sternb.) Berry on the basis of the typical pinnately lobed leaves and the characteristic venation of lobes. This taxon is typical fruticose element in deposits of the Most Basin, mainly at the base of the Overlying Member of the Most Formation, Břešťany clay and sand-clay facie of the Žatec delta (Kvaček and Bůžek 1982).

Juglandaceae

Genus *Carya* Nutt.

Carya cf. *serrifolia* (Goeppert 1855) Kräusel 1921
Pl. 2, fig. 2, pl. 3, fig. 9, Fig. 2.13

1869 *Pterocarya denticulata* (Web.) Heer; Ettingshausen, p. 47, pl. 53, figs. 11–15.
1891 *Pterocarya denticulata* (Web.) Heer; Engelhardt, p. 193, pl. 17, figs. 15, 17.
1904 *Pterocarya denticulata* (Web.) Heer; Brabenec, p. 10.
1904 *Evonymus proserpinae* Ett.; Brabenec, p. 18.
1904 *Aesculus palaeocastanum* Ett.; Brabenec, p. 22.
1971 *Carya* cf. *serrifolia* (Goepp.) Kräusel; Bůžek, p. 45, pl. 12, figs. 1–16, pl. 13, figs. 1–4.

Material: 6 incomplete leaflets (impressions).

Description: Leaflets oblong to elliptic, 56 to 74 mm long and 20 to 27 mm broad, base cuneate, rarely with a fragmentary petiole (4 mm long), apex not preserved, probably acute; margin regularly finely serrate, teeth triangular, acute; venation semicraspedodromous, midrib strong, moderate, straight, secondary veins straight, distinct, alternate, numerous, originating at 60 to 70°, tertiary veins numerous, thin, perpendicular; venation of higher orders creating a regular polygonal net.

Remarks: The material from Přívlaky is morphologically similar to the occurrences of slender leaflets, which were described from the Pětipsy area and from Holedeč (Bůžek 1971, Brabenec 1904, Teodoridis 2002). Therefore it can be assigned to *Carya* cf. *serrifolia* (Goepp.) Kräusel sensu Bůžek 1971 on the basis of similarity in their leaf morphology (mainly form and semicraspedodromous type of venation) and also due to co-occurrence of *Carya bohemica* Brabenec 1904 from Holedeč.

Ebenaceae

Genus *Diospyros* L.

cf. *Diospyros brachysepala* Al. Br. 1845 sensu Hantke 1954
Pl. 3, fig. 5, Fig. 2.2

1845 *Diospyros brachysepala* Al. Br.; Braun, p. 170.
1859 *Diospyros brachysepala* Al. Br.; Heer, p. 11, 191, pl. 10, figs. 1–12, 14(?).
1954 *Diospyros brachysepala* Al. Br.; Hantke, p. 80, pl. 14, figs. 4–6.
1971 *Diospyros brachysepala* Al. Br. sensu Hantke; Bůžek, p. 65, pl. 26, figs. 1–12.

Material: 1 fragment of leaf (impression).

Description: Leaf fragment oval, 42 mm long and 34 mm broad, base narrowly cuneate, apex not preserved; margin entire; venation brochidodromous, midrib strong, moderate, curved, secondary veins alternate, looping, intersecondary veins very thin, parallel with secondary veins, venation of higher orders poorly preserved.

Remarks: The fragment can be assigned to cf. *Diospyros brachysepala* Al. Br. sensu Hantke on the basis of typical morphological features (i. e., leaf form, looping of secondary venation, parallel intersecondary veins). The impression described above is morphologically similar to the leaf material from the Pětipsy area (Bůžek 1971), where the affinity to the genus *Diospyros* L. is corroborated by the occurrence of a calyx.

Salicaceae

Genus *Salix* L.

Salix haidingeri Ettingshausen 1866 emend. Bůžek 1971
Pl. 3, fig. 4, Fig. 2.1

1866 *Salix haidingeri* Ett.; Ettingshausen partim, p. 88, pl. 29, figs. 9–13, 15, 16, non fig. 8.
1881 *Salix angusta* Al. Br.; Engelhardt, p. 81, pl. 1, fig. 17.
1971 *Salix haidingeri* Ett. emend. Bůžek; Bůžek, p. 66, pl. 35, figs. 1–10, pl. 36, figs. 1–12, text-fig. 8.

Material: 9 incomplete leaf and 3 fragments (impressions).

Description: Leaf narrow elongate to linear, 38 to 83 mm long and 7 to 16 mm broad, base cuneate with a fragmentary petiole (5 mm long), apex acute; margin entire or crenulate to serrate with fine teeth; venation camptodromous, midrib distinct, strong, moderate, straight, secondary veins numerous, alternate, looping, originating at 45 to 65°, rare intersecondary veins very thin, parallel with secondary veins, tertiary veins and venation of higher orders poorly preserved.

Remarks: This material is assigned to *Salix haidingeri* Ett. emend. Bůžek on the basis of the leaf form, character of the margin and course of the venation. Bůžek (1971) has defined a new concept of *Salix haidingeri* Ett., when he combined fine serrate forms (*Salix lavateri* Al. Br. or *Salix haidingeri* Ett.) with entire forms (*Salix angusta* Al. Br.) to one species *Salix haidingeri* Ett. emend. Bůžek.

Genus *Populus* L.

cf. *Populus populina* (Brongniart 1822) Knobloch 1964
Pl. 3, fig. 1, Figs. 2.11, 25

1822 *Phyllites populina* Brongniart; p. 237, pl. 14, fig. 4.
1836 *Populus latior* Al. Br.; Braun in Buckland, p. 512.
1964 *Populus populina* (Brongn.) Knobloch; p. 601.

Material: 3 complete and incomplete leaves (impressions).

Description: Leaves round to broadly ovate, 50 to 76 mm long and 51 to 86 mm broad, base broad cuneate to rounded, rare cordate (G/pa 212-1), apices not preserved; margin regularly coarse dentate; venation semicraspedodromous to craspedodromous, midrib strong, moderate, straight, secondary veins usually looping, basal pair is very distinct, alternate or opposite (first basal pair), originating at acute angle, creating loops and branched in thin veins (Tertiary), innervating apices of teeth, tertiary veins and venation of higher orders poorly preserved.

Remarks: These incomplete leaves are assigned to *Populus populina* (Brongn.) Knobloch on the basis of the

leaf form, type and course of the venation (branching of the distinct first basal secondary veins pair) and entire base. The latter feature is important for differentiation to the taxon *Populus zaddachii* Heer var. *brabenecii* (Teodoridis 2002). Fragments of the basal leaf part are also similar to fragments of the genus *Parrotia* C. A. Mey. The leaf impression (G/pa 212-1) is very similar to Heer's type material (Heer 1856), which was originally described as *Populus latior* Al. Br. f. *cordifolia* (Heer 1856: p. 12, pl. 55, fig. 4).

Populus sp.
Fig. 2.21

Material: 4 fragments of leaves (impressions).

Description: Leaf fragments ovate, maximally 80 mm long and 66 mm broad, base narrowly round to broad cuneate, apex not preserved; margin crenulate, rare simple serrate; venation semicraspedodromous; midrib strong, moderate, straight, secondary veins looping, basal pair very distinct, alternate, partly opposite, curved towards to apex and margin, originating at acute angle, intersecondary veins thin, parallel with secondary veins, both venation creating loops and branched in dense net in marginal part; tertiary veins perpendicular, forked and with venation of higher orders creating a polygonal net.

Remarks: The material from Přívlaky is very fragmentary and typical of the specific course of the secondary veins. The latter feature is very poorly preserved. Leaf impressions, which are describe as *Populus zaddachii* Heer var. *brabenecii* from Holedeč (orig. Brabenec 1904) and Hlavačov (Teodoridis 2002) are very similar in the course of the secondary venation and also in the base form. On the other hand, the material from Přívlaky shows also affinity to *Populus populina* (Brong.) Knobloch. According to fragmentary character of material and poor preservation it is assigned to *Populus* sp.

Ulmaceae

Genus *Ulmus* L.

Ulmus pyramidalis Goeppert 1855
Pl. 3, fig. 8, Fig. 2.18

1845 *Ulmus bronni* Unger; pl. 26, fig. 1, non figs. 2–4.
1855 *Ulmus pyramidalis* Goeppert; p. 29, pl. 13, figs. 10–12.
1866 *Ulmus minuta* Goepp.; Ettingshausen, p. 64, pl. 18, figs. 21, 22.
1866 *Planera ungeri* Ettingshausen; p. 65, pl. 18, figs. 14–16, 18(?), 19(?), non figs. 17, 20.

Material: 14 incomplete and fragments of leaves (impressions).

Description: Leaves more or less asymmetric, elliptic to ovate, of medium size, base round to slightly cordate, apex attenuate to acute; margin double-dentate to partly tripli-dentate with rectangular primary teeth, secondary teeth usually finer; venation simple craspedodromous, midrib strong, moderate, straight, secondary veins distinct, alternate to opposite, parallel, numerous, originating at acute angles, curved towards to apex and margin, innervating apices of primary teeth, tertiary veins straight or forked, innervating apices of secondary teeth, tertiary veins and venation of higher orders creating a dense polygonal net, poorly preserved.

Remarks: The leaf material is assigned to *Ulmus pyramidalis* Goepp. on the basis of the distinctly dentate margin and the closely spaced parallel secondaries. The material is variable in size, form and character of margin, but these morphological differences can be regarded as intraspecific variability of leaves. The leaves from Přívlaky match the material from the localities Holedeč and the "Hlavačov gravel and sand".

Genus *Zelkova* Spach

Zelkova zelkovifolia (Unger 1843) Bůžek et Kotlaba in Kotlaba 1963
Pl. 3, figs. 6, 10, Fig. 2.14

1843 *Ulmus zelkovaefolia* Unger; pl. 24, figs. 9–13, non fig. 7 (fructus).
1851 *Zelkova ungeri* (Ett.). Kov.; Anonymus (ref. Kováts), p. 178 .
1851 *Planera ungeri* Ettingshausen; p. 14, pl. 2, figs. 5(?), 6(?), 7–9, 10–12(?), 13, 14, 16, non figs. 15, 17, 18.
1963 *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotl.; Kotlaba, p. 59, pl. 3, figs. 7, 8.
1971 *Zelkova zelkovaefolia* (Ung.) Bůžek et Kotl.; Bůžek, p. 58, pl. 21, figs. 8, 9, pl. 22, figs. 4–14, text-fig. 5.

Material: 14 complete and incomplete leaves.

Description: Leaves often asymmetrical, ovate to oblong ovate, 23 to 56 mm long and 16 to 30 mm broad, base round, apex shortly acute; margin coarse simple-serrate; venation simple craspedodromous, midrib strong, moderate, straight, secondary veins distinct, parallel, alternate, originating at 50 to 70°, curved towards to apex and margin, innervating apices of teeth, tertiary veins and venation of higher order not preserved.

Remarks: The leaves are assigned to *Zelkova zelkovifolia* (Ung.) Bůžek et Kotlaba on the basis of the characteristic coarse simple-serrate margin and the whole leaf form. The material from Přívlaky is also identical to the leaf material from the Pětipsy area (Bůžek 1971).

Rosaceae

Genus *Rosa* L.

Rosa europaea (Ettingshausen 1868) Z. Kvaček et Hurník 2000
Pl. 2, fig. 6, Fig. 2.10

1868 *Myrsine europaea* Ettingshausen; p. 37, pl. 37, fig. 22,
1971 *Rosa bohemica* Engelh.; Bůžek, p. 61, pl. 24, figs. 1–19.
2000 *Rosa europaea* (Ett.) Z. Kvaček et Hurník; p. 15, pl. 6, figs. 1, 9, text-figs. 3.3, 4.8, 5.11, 5.14.

Material: 5 complete leaflets (impressions).

Description: Leaflets ovate to obovate, 32 to 36 mm long and 19 to 20 mm broad, base asymmetric, round, apex

obtuse; margin simple serrate, entire in basal part, teeth 1 to 1.5 mm broad at base, convex; venation craspedodromous to semicraspedodromous, midrib strong, secondary veins numerous, alternate, originating at 40 to 50°, venation of higher order not preserved.

Remarks: The leaflets can be assigned to *Rosa europaea* (Ett.) Z. Kvaček et Hurník on the basis of the morphological features (mainly the size, form of asymmetric base and the character of margin) and also due to morphological comparison to the leaf material from Čermníky (Bůžek 1971) from localities Želénky, Zabrušany and Vršovice (Kvaček and Hurník 2000) and from the localities Velká Černoc and Holedeč (Teodoridis 2002). The material is morphologically very similar to small leaves of *Zelkova zelkovifolia* (Ung.) Bůžek et Kotlaba, which are mostly different in the character of the leaf base and numerous secondary veins.

Leguminosae

Genus *Podocarpium* Al Braun ex Stizenberger

Podocarpium podocarpum (Al. Braun in Buckland 1836) Herendeen 1992
Pl. 2, figs. 9, 10, Fig. 2.7

1836 *Gleditschia podocarpa* Al. Br.; Braun in Buckland, p. 513.
1851 *Podocarpium knorri* Al. Br.; Braun in Stizenberger, p. 90.
1859 *Podogonium knorri* Heer; p. 114, pl. 134, figs. 22–26a, pl. 35, non fig. 19, pl. 136, figs. 1–9.
1971 *Podogonium oehningense* (Koenig) Kirchheimer; Bůžek, p. 98–99, pl. 47, fig. 9, pl. 50, figs. 1–27, pl. 51, figs. 1–12, text-fig. 16.
1992 *Podocarpium podocarpum* (Al. Br.) Herendeen; p. 732.

Material: 20 isolated complete and fragmentary leaflets (impressions).

Description: Leaflets oval to ovate, 14 to 35 mm long and 3 to 13 mm broad, apex abtuse or acute, base asymmetric, cuneate to rounded often with fragments of short petiole; margin entire; venation camptodromous, midrib strong, straight, secondary veins and venation of higher orders poorly preserved.

Remarks: Both complete and fragmentary leaflets are assigned to *Podocarpium podocarpum* (Al. Br.) Herendeen, namely on the basis of the morphological parameters of the leaflets (size, form, asymmetry of base) and also comparison to the material from the Pětipsy area (Bůžek 1971). There is no doubt about affinity of smaller leaflets, which probably belong to the apical part of compound leaves. Assigning of the two larger leaflets (PŘ 120 and PŘ 18) to the genus *Podocarpium* is equivocal. Due to their morphological parameters, these impressions can be also similar to entire leaves, which were described as *Myrica* sp. by Teodoridis (2002: pl. 4, fig. 5) from Nesuchyně.

Vitaceae

Genus *Vitis* L.

cf. *Vitis stricta* (Goeppert 1855) Knobloch 1969
Pl. 1, fig. 5, Fig. 2.20

1855 *Acer strictum* Goeppert; p. 35, pl. 23, figs. 1–5.
1861 *Vitis teutonica* Al. Br.; Unger, p. 23, pl. 9, figs. 1–8.
1885 *Vitis teutonica* Al. Br.; Engelhard;. p. 342, pl. 10 (17), figs. 1, 6, 7.
1969 *Vitis strictum* (Goepp.) Knobloch; p. 125, pl. 64, fig. 9, fig. 296.

Material: 1 incomplete leaf (impression).

Description: Leaf palmately 3- lobed, 98 mm long, 57 mm broad, apices acute, base incompleted, probably broadly rounded or cordate, central lobe distinct triangular, lateral lobes triangular in basal part broadened, sinuses round, open; margin irregular dentate; venation basal actinodromous, 2 (3 originaly) primary veins strong, moderate, apices of lobes, originating at 51°, secondary venation looping and thinner veins innervating teeth, tertiary veins perpendicular or forked.

Remarks: This incomplete leaf can be assigned to cf. *Vitis stricta* (Goepp.) Knobloch on the basis of the morphological features (mainly form and type of the margin) and morphological resemblance to the leaves, which were described earlier (e.g., Knobloch 1969: pl. 64, fig. 9, and Mai and Walther 1991: pl. 38, fig. 1, text-figs. 6.12). Smaller differences in innervation of the secondary veins are not so significant for determination and can be interpreted as intraspecies variability.

Anacardiaceae

Toxicodendron Mill. vel *Rhus* L.

cf. *Toxicodendron* sp.
Pl. 1, fig 4, Fig. 2.22

Material: Only 1 fragment of leaflet (impression).

Description: Leaflet probably elliptic or oval, 43 mm long and 31 mm broad, apex not preserved, base asymmetric, widely cuneate, petiole not preserved, margin entire in basal part, simple-serrate in upper part; venation semicraspedodromous, midrib strong, distinct, curved, moderate, secondary veins thin, alternate, originating at 20 to 40°, venation of higher order poorly preserved.

Remarks: The material is probably assigned as cf. *Toxicodendron* sp. The determination is based on the leaflet morphology (e.g., asymmetric base, character of the margin and course of the venation) and also due to morphological comparison to material from Kundratice (Kvaček and Walther 1998). Secretory elements, which are described on veins of the material from Kundratice, are not preserved on material from Přívlaky, therefore the assigning is equivocal.

Sapindaceae

Genus *Sapindus* L.

"*Sapindus*" *falcifolius* (Al. Braun in Buckland 1836) Al. Braun in Stizenberger 1851
Pl. 3, fig. 3, Fig. 2.12

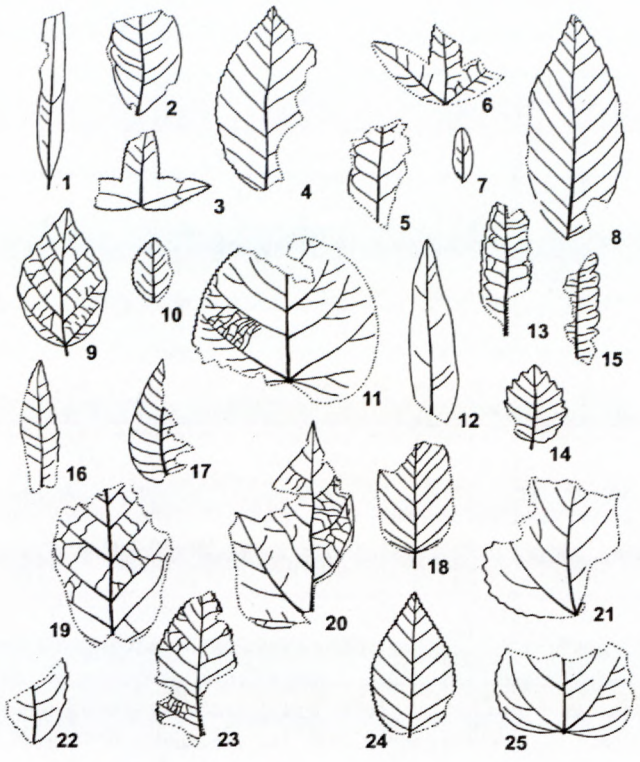


Fig. 2. Floral picture of the locality Přívlaky (x 0.5)
(sign. G/pa – material from the Regional Museum at Most, sign. PŘ – material from the Faculty of Science, Charles University in Prague).
1 – *Salix haidingeri* Ett. emend. Bůžek, PŘ – 101, 2 – cf. *Diospyros brachysepala* Al. Br. sensu Hantke, PŘ – 107, 3 – *Liquidambar europaea* Al. Br. in Buckland, PŘ – 106, 4 – *Alnus* sp. sensu Bůžek, PŘ – 93, 5 – *Dicotylophyllum* sp. 2, PŘ – 46, 6 – *Acer dasycarpoides* Heer sensu Procházka et Bůžek, G/pa 211-1, 7 – *Podocarpium podocarpum* (Al. Br. in Buckland) Herendeen, PŘ – 116, 8 – *Fagus saxonica* Z. Kvaček et Walther, G/pa 214-2, 9 – *Parrotia pristina* (Ett.) Stur sensu Bůžek, PŘ – 88, 10 – *Rosa europaea* (Ett.) Z. Kvaček et Hurník, G/pa 205-1, 11 – cf. *Populus populina* (Brong.) Knobloch, G/pa 212-1, 12 – *"Sapindus" falcifolius* (Al. Br.) Al. Braun, G/pa 216/1, 13 – *Carya* cf. *serrifolia* (Goepp.) Kräusel, G/pa 216/1, 14 – *Zelkova zelkovifolia* (Ung.) Bůžek et Kotlaba in Kotlaba, PŘ – 86, 15 – *Comptonia difformis* (Sternb.) Berry, PŘ – 51, 16 – cf. *Myrica* sp., PŘ – 137, 17 – *Dicotylophyllum* sp. 1, PŘ – 48, 18 – *Ulmus pyramidalis* Goepp., PŘ – 41, 19 – *Alnus* sp. sensu Bůžek, G/pa 216-1, 20 – cf. *Vitis stricta* (Goepp.) Knobloch, PŘ – 76, 21 – *Populus* sp., PŘ – 49, 22 – cf. *Toxicodendron* sp., G/pa 211-2, 23 – *Betula* sp., PŘ – 72, 24 – *Alnus* sp. sensu Bůžek, PŘ – 63, 25 – cf. *Populus populina* (Brong.) Knobloch, PŘ – 77.

1836 *Juglans falcifolius* Al. Br.; Braun in Buckland, p. 513.
1851 *Sapindus falcifolius* (Al. Br.) Al. Br.; Braun in Stizenberger, p. 87.
1971 *Sapindus falcifolius* (Al. Br.) Al. Br.; Bůžek, p. 82, pl. 35, figs. 1–6, text-fig. 12.

Material: 6 fragments and incomplete leaflets (impressions).

Description: Fragments of leaflets oblong to ovate, 35 to 88 mm long and 11 to 24 mm broad, apex acute, base narrowly cuneate and asymmetrical; margin entire; venation eucamptodromous, midrib strong, straight, secondary veins distinct, relatively numerous, alternate, originating at 40 to 50°, venation of higher orders poorly preserved.

Remarks: The leaflets can be assigned to *"Sapindus" falcifolius* (Al. Br.) Al. Br. on the basis of the typical entire margin, asymmetrical base and the characteristic course of secondary veins. This material is also well comparable to leaflets of Pětipsy area (Bůžek 1971) or material from Julius Fučík mine (Kvaček 1960). The fragments are similar to entire forms of *Salix varians* Goepp. Main differences of the determination of the both taxa are asymmetrical base (typical feature of compound leaves), other course and originating of the secondary veins (in the case of *Salix* less acute angles) and differences in form and width of leaves or leaflets.

Aceraceae

Acer L.

Acer dasycarpoides Heer 1859 sensu Procházka et Bůžek 1975
Pl. 3, fig. 2, Fig. 2.6

1859 *Acer dasycarpoides* Heer; p. 198, pl. 114, figs. 3, 9, pl. 115, fig. 6, pl. 155, figs. 6–8.
1904 *Acer rüminianum* Heer; Brabenec, p. 19.
1975 *Acer dasycarpoides* Heer sensu Procházka et Bůžek; p. 36–42, pl. 21, figs. 6–10, text-figs. 4a–c, 14, 15.

Material: 2 incomplete leaves (impressions)

Description: Leaves palmately 3- lobed, 26 and 38 mm long, 35 and 58 mm broad, base round, lobes oblong to lanceolate, same in size, apices acute, sinuses round, open; margin simple serrate; venation basal actinodromous, 3 primary veins strong, moderate, originating at 50 and 60°; secondary veins, alternate, originating at acute angles, looping and innervating individual apices of teeth; tertiary veins straight or forked with venation of higher order creating dense polygonal net.

Remarks: The incomplete leaves can be assigned to *Acer dasycarpoides* Heer sensu Procházka et Bůžek on the basis of the leaf morphology (mainly typical 3- lobed leaf and typical form of the lobes). According to Procházka and Bůžek (1975) the material corresponds to primitive form *A. dasycarpoides* Heer f. *angustilobum* with relatively narrower lobes. It is also very similar to occurrences from the surroundings of Holedeč (Teodoridis 2002).

Plantae incertae sedis

Dicotylophyllum sp. 1
Pl. 2, fig. 5, Fig. 2.17

Material: 1 incomplete leaflet (PŘ – 48).

Description: Leaflets ovate, 59 mm long and 28 mm broad, base slightly cordate, apex acute; margin entire; venation brochidodromous, midrib strong, moderate, curved, secondary veins looping, distinct, opposite at basal part, alternate, numerous (13 pairs), originating at 40 to 80°, venation of higher orders not preserved.

Remarks: This incomplete leaf fossil is probably a lateral or terminal leaflet of compound leaves, which is not possible to determinate without epidermal analyse. This impression is morphologically similar to representatives of the genus *Juglans* L., but they have broader spacing of secondary vein pairs.

Dicotylophyllum sp. 2
Pl. 1, fig. 9, Fig. 2.5

Material: 1 fragment of leaf (PŘ – 46).

Description: Leaf probably oblong or elliptic, 51 mm long and 26 mm broad, base and apex not preserved; margin irregularly finely serrate, teeth triangular, acute; venation semicraspedodromous, midrib strong, straight, secondary veins distinct, alternate, originating at 65 to 80°, tertiary veins numerous, thin, perpendicular or forked, venation of higher orders creating a regular polygonal net.

Remarks: The leaf fragment is very similar to the illustration of the missing leaf fragment from the locality Nesuchyně. This impression was described as *Myrica* sp. and published by Teodoridis (2002: pl. 2, fig. 10).

ECOLOGICAL INTERPRETATION OF VEGETATIVE COVER

The locality Přívlaky has yielded 22 taxa of angiosperms – dicots (including 2 taxa of *Incertae sedis*) – see table 1 and Fig. 2. The floristic association is interesting of total absence of conifers and ferns. This fact in the case of conifers can be explained by absence of typical back swamp associations. I suppose ecological pressure due to higher density of shrub storey in the case of herbaceous ferns.

The overall vegetation of Přívlaky can be interpreted as a relatively temperate riparian forest with dominating deciduous elements on humid habitats (Fig. 3). The vegetative cover can be divided into 2 relatively independent associations, which are bound to specific environmental conditions. These associations mutually integrate on ecotones. The first association can be defined as an ***Association of wet soils***. This association is typical of plants, which prefer waterlogged substrates and it is characteristic of riparian ecosystems. It includes *Ulmus pyramidalis*, *"Parrotia" pristina*, *Alnus* sp., *Fagus saxonica*, *Liquidambar europaea*, cf. *Populus populina*, *Populus* sp., *Rosa europaea*, *Salix haidingeri* and cf. *Myrica* sp. The latter taxon is usually interpreted as a typical element of the back swamp association (it is also possible due to allochtonous taphocenosis from Přívlaky in this case), but on the other hand it is possible to interpret it as member of wet soils association due to similar ecological factors on mutual ecotons. The wet soils association (in my sense) is close to



Fig. 3. Reconstruction of vegetation cover at the locality Přívlaky. Ad – *Acer dasycarpoides*, Al – *Alnus* sp., Be – *Betula* sp., Co – *Comptonia difformis*, Cy – *Carya* cf. *serrifolia*, Fa – *Fagus saxonica*, Li – *Liquidambar europaea*, My – *Myrica* sp., Pa – *Parrotia pristina*, Pd – *Podocarpium podocarpum*, Po – *Populus* sp., Ro – *Rosa europaea*, Sa – *"Sapindus" facifolius*, Sh – *Salix haidingeri*, To – cf. *Toxicodendron* sp., Ul – *Ulmus pyramidalis*, Vi – *Vitis stricta*, Ze – *Zelkova zelkovifolia*.

the association of *Parrotia – Ulmus pyramidalis*, which was defined by Kvaček and Bůžek (1982). It is typical of its fruticose elements and elements of riparian forests, which occupied areas along rivers and deltas. The second plant association, which can be defined on the locality Přívlaky, is an ***Association of slopes***. It is mainly typical of mesophytic elements (Mixed Mesophytic Forest), which are bound in principle to humid environment, but do not tolerate too much waterlogged soils. It includes *Comptonia difformis*, *Carya* cf. *serrifolia*, *Zelkova zelkovifolia*, *Betula* sp., cf. *Vitis stricta*, *Acer dasycarpoides*, *"Sapindus" falcifolius*, *Podocarpium podocarpum* and cf. *Diospyros brachysepala*. The canopy was differentiated into high trees – E4 (e.g., *Zelkova* and *Carya*) and smaller trees – E3 (e.g., *Alnus*, *Betula*, *Fagus*, *Populus*, *Diospyros*, *Acer*, *"Sapindus"*). The understorey was represented by shrubs – E2 (e.g., *Salix*, *Comptonia*, *"Parrotia"*, *Rosa*, *Podocarpium*, *Myrica*) and lianas – E2 (e.g., *Vitis*, *Toxicodendron*) – see table 1.

STRATIGRAPHY AND FLORISTIC CORRELATION

According to the floristic analysis of the locality Přívlaky, it could be said, the flora has affinity to the floras, which were

Table 1. Summary of the floristic composition on the locality Přívlaky (frequence classes: * - rare, ** - common, * - dominant; E – forest storeys: E4 – trees over 25 m high, E3 – trees under 25 m high, E2 – shrubs and lianas).**

taxa	storey	frequence	taxa	storey	frequence
Acer dasycarpoides	E3	*	*"Parrotia" pristina*	E2	**
Alnus sp.	E3	***	cf. *Populus populina*	E3	*
Betula sp.	E3	***	*Populus* sp.	E3	**
Carya cf. *serrifolia*	E4	**	*Podocarpium podocarpum*	E2	***
Comptonia difformis	E2	***	*Rosa europaea*	E2	**
Dicotylophyllum sp.1	E4	*	*Salix haidingeri*	E2	***
Dicotylophyllum sp.2	E2	*	*"Sapindus" falcifolius*	E3	**
cf. *Diospyros barchysepala*	E3	*	cf. *Toxicodendron* sp.	E2	*
Fagus saxonica	E3	***	*Ulmus pyramidalis*	E3	***
Liquidambar europaea	E3	*	cf. *Vitis stricta*	E2	*
cf. *Myrica* sp.	E2	*	*Zelkova zelkovifolia*	E4	**

described by Bůžek (1971) from the Pětipsy area and also with the floras, which were described by Teodoridis (2002) from individual localities of the "Hlavačov gravel and sand" and from Holedeč. The latter mentioned floras are correlated on the basis of the similar floristic association (mainly common occurrences of *Pseudolarix schmidtgenii* and *Fagus saxonica*) with the Upper Oligocene floristic assemblage Thierbach in sense of Mai and Walther (1991). According to Bůžek (1971) the floras from the Pětipsy area are divided into three floristic associations, which correspond to various stratigraphical positions (Underlying Member, Upper inter-seam Member and Overlying Member of the Most Formation – Early Miocene). The floras from the Upper inter-seam Member of the Most Formation are most numerous and closest to the flora from Přívlaky. The composition of both floras i.e., the Pětipsy area and the "Hlavačov gravel and sand" including Holedeč is more or less similar. The difference between them is in relative abundance of leaf occurrences of *Fagus saxonica*. This taxon is a very important element of the Upper Oligocene floras, e.g., the floras from Thierbach (Mai and Walther 1991), from Kleinsaubernitz near Bautzen (Walther 1999) or the volcanic floras from the localities Počerny and Podlesí of the Sokolov Basin (Kvaček et al. 1989). Mai (1995) refers the two latter mentioned floras to the floristic assemblage of Rott – Thierbach, Upper Oligocene in age. According to already mentioned occurrences of *Fagus saxonica* I correlate the flora from Přívlaky with the Upper Oligocene floristic assemblage of Thierbach or with floristic assemblage Linz – Krunvíř of the Upper Oligocene–Lowest Miocene (Kvaček and Walther 2001). Therefore I suppose that the deposits of surroundings of Přívlaky are isolated remnants of erosion processes, which could be matched to the Tertiary system of the Central River (Pešek and Spudil 1986) or its equivalent delta sediments. For further data see Teodoridis (2004).

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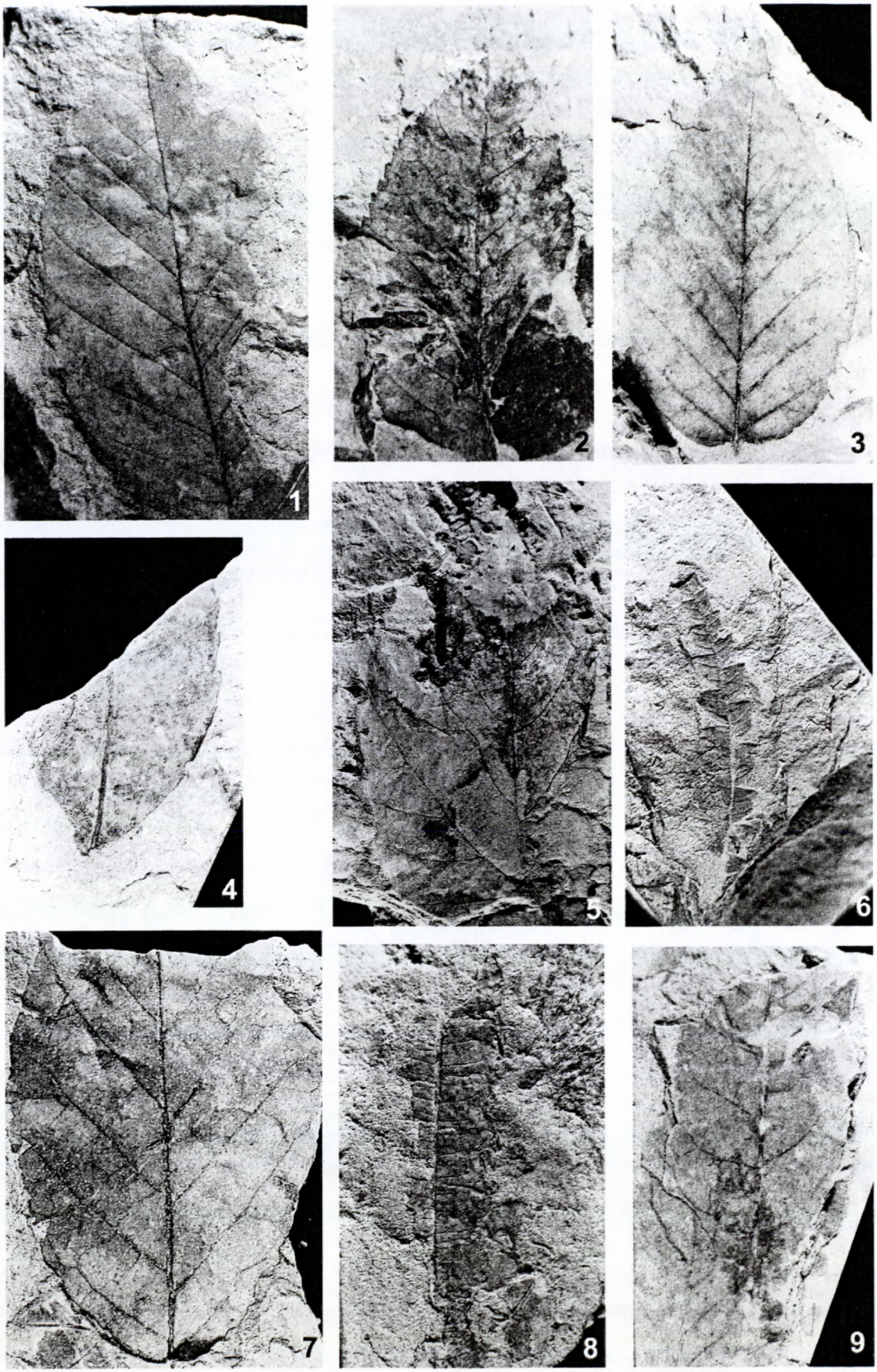


Plate 1
(sign. G/pa – material from the Regional Museum at Most, sign. PŘ – material from the Faculty of Science, Charles University in Prague).
1 – *Alnus* sp. sensu Bůžek 1971, PŘ – 93, 1x,
2 – *Betula* sp., PŘ – 72, 1x,
3 – *Alnus* sp. sensu Bůžek 1971, PŘ – 63, 1x,
4 – cf. *Toxicodendron* sp., G/pa 211-2, 1x,
5 – cf. *Vitis stricta* (Goepp.) Knobloch, PŘ – 76, 0.75x,
6 – *Comptonia difformis* (Sternb.) Berry, G/pa 209- 1, 1x,
7 – *Alnus* sp. sensu Bůžek 1971, G/pa 216-2, 1x,
8 – *Comptonia difformis* (Sternb.) Berry, PŘ – 51, 1x,
9 – *Dicotylophyllum* sp. 2, PŘ – 46, 1x.

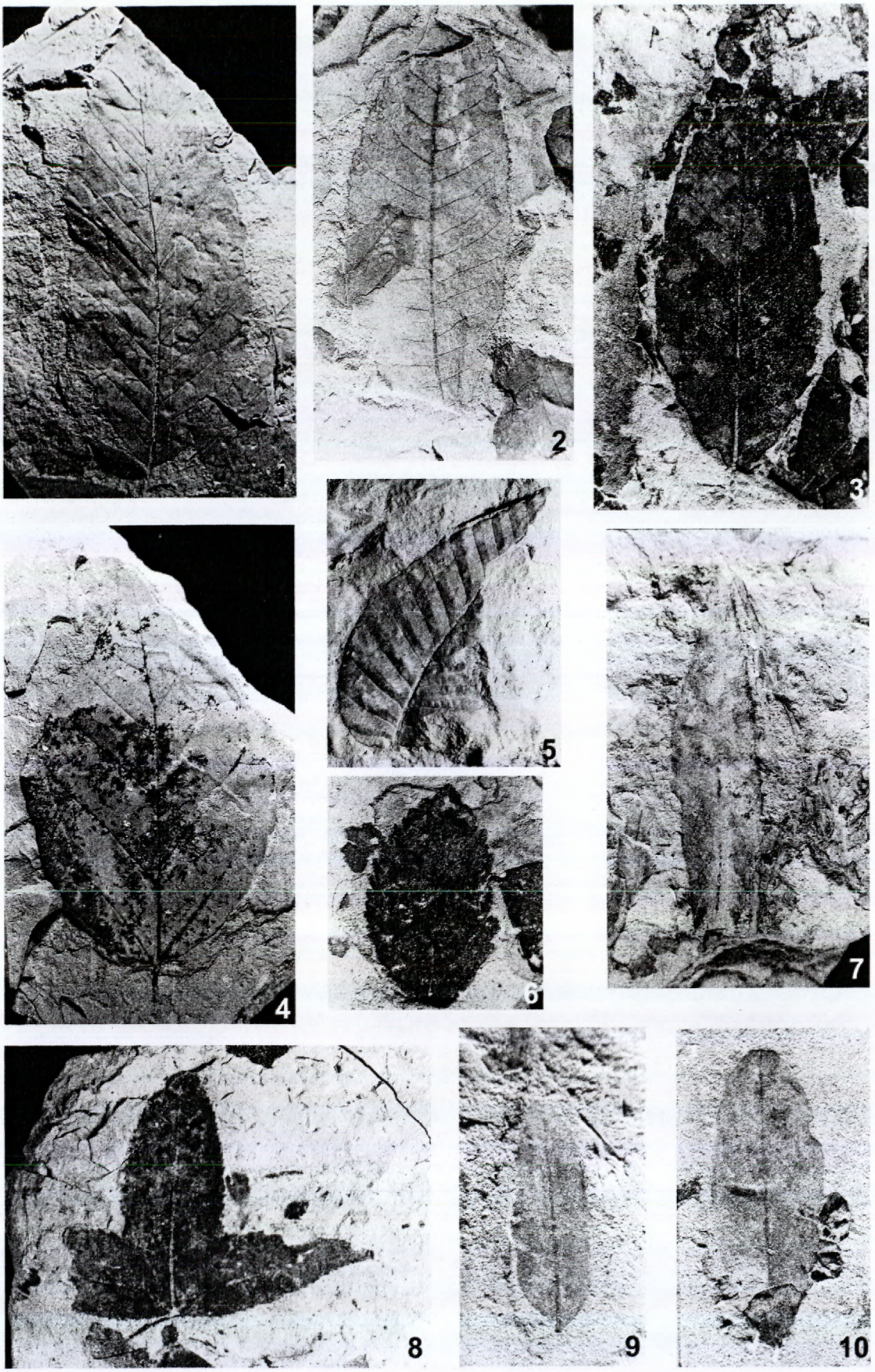


Plate 2

1 – *Fagus saxonica* Z. Kvaček et Walther, PŘ – 54, 1x,
2 – *Carya* cf. *serrifolia* (Goepp.) Kräusel, G/pa 214-3, 1x,
3 – *Fagus saxonica* Z. Kvaček et Walther, PŘ – 28, 1x,
4 – *Parrotia pristina* (Ett.) Stur sensu Bůžek, PŘ – 88, 1x,
5 – *Dicotylophyllum* sp. 1, PŘ – 48, 1x,
6 – *Rosa europaea* (Ett.) Z. Kvaček et Hurník, G/pa 209-1, 1x,
7 – cf. *Myrica* sp., PŘ – 137, 1x,
8 – *Liquidambar europaea* Al. Braun in Buckland, PŘ – 106, 1x,
9 – *Podocarpium podocarpum* (Al. Br. in Buckland) Herendeen, PŘ – 116, 1.4x,
10 – *Podocarpium podocarpum* (Al. Br. in Buckland) Herendeen, PŘ – 103, 1.4x.

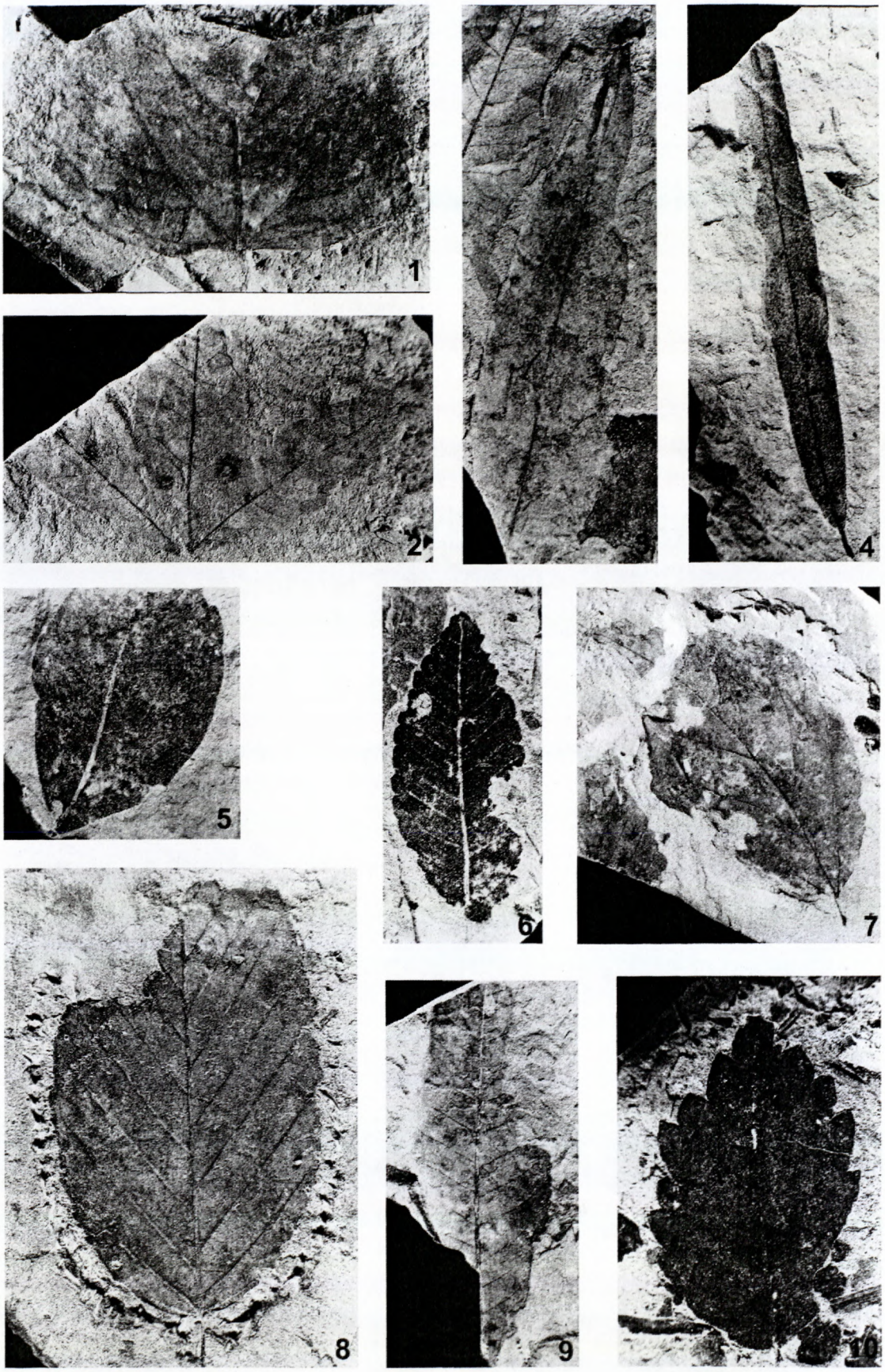


Plate 3

1 – cf. *Populus populina* (Brong.) Knobloch, PŘ – 77, 1x,
2 – *Acer dasycarpoides* Heer sensu Procházka et Bůžek, G/pa 211-1, 1x,
3 – *"Sapindus" falcifolius* (Al. Br.) Al. Br., G/pa 216-1, 1x,
4 – *Salix haidingeri* Ett. emend. Bůžek, PŘ – 101, 1x,
5 – cf. *Diospyros brachysepala* Al. Br. sensu Hantke, PŘ – 107, 1x,
6 – *Zelkova zelkovifolia* (Ung.) Bůžek et Kotlaba in Kotlaba, G/pa 216-3, 1.4x,
7 – *Parrotia pristina* (Ett.) Stur sensu Bůžek, PŘ – 98, 1x,
8 – *Ulmus pyramidalis* Goepp., PŘ – 41, 1.2x,
9 – *Carya* cf. *serrifolia* (Goepp.) Kräusel, PŘ – 82, 1x,
10 – *Zelkova zelkovifolia* (Ung.) Bůžek et Kotlaba in Kotlaba, PŘ – 86, 1.4x.

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MICROFACIES OF THE SILURIAN-DEVONIAN BOUNDARY INTERVAL IN SOME SECTIONS IN THE BARRANDIAN AREA (CZECH REPUBLIC)

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Abstract: The carbonate rocks of the Silurian-Devonian boundary interval in the NE part of the Barrandian area were studied by microfacies analysis, which allows a reconstruction of depositional environment and processes of origin of the sediments. The shallowing trend of sedimentary basin during the Upper Přídolí and the Lower Lochkovian is demonstrable. The deposition by traction currents is considered as the most probable process of genesis of micritic limestones in the studied interval. Coarse-grained bioclastic limestones can be classified as debris flows.

INTRODUCTION

The Silurian-Devonian boundary is represented in the Barrandian area in purely marine carbonates sequences. The boundary interval was subjected to very detailed geological and biostratigraphical studies in the last decades (Chlupáč 1953, Chlupáč et al. 1972, Chlupáč and Kukal 1977), but detailed sedimentological research was almost neglected up to now. Microfacies analysis by Hladil (1991, 1992) was carried out at the international boundary stratotype at Klonk near Suchomasty.

In this paper the results of microfacies analysis sensu Wilson (1975) in three sections in the NE part of the Prague Basin are presented (area between Praha-Radotín, Řeporyje and Podolí, Fig. 1).

The classification of Wilson (1975) is based on standard microfacies (SMF) studied at the Mesozoic and Cenozoic carbonates. Many texture elements are typical both for Mesozoic and Early Palaeozoic sediments and make the method useful for investigated sedimentary rocks.

STUDIED SECTIONS

The first studied section is situated in abandoned "Požáry" quarry at Praha-Řeporyje (Fig 1.1, Fig. 2). The Silurian-Devonian boundary is developed in a purely carbonate sequence. Coarse-grained bioclastic (crinoidal) limestones are unsorted, their clasts poorly rounded. Most of micrite was washed-out by the wave activity. Fauna of these beds is typically shallow-water – crinoids and brachiopods predominate. Sedimentary breccia was found in the lower part of the Lochkov Formation. This type could be classified as SMF 5 (alternatively SMF 9, 12) after Wilson (1975) (composition see tab. 1). This microfacies corresponds to the Facies Belt 4 (= foreslope of carbonate platform, depth several metres to several tens of metres). Organic detritus originated from carbonate buildup was deposited there by debris flows. The section belongs to the area of shallow-water development of the Požáry Formation – Lochkov Formation boundary interval (Kotýs Limestone).

The second studied section is situated about 100 m SW from the well known palaentological locality "Antipleura Gorge" in Praha-Radotín (Fig. 1.2, Fig. 2). The uppermost part of the Požáry Formation consists of platy, dark grey micritic bituminous limestones alternating with black calcareous shale interbeds (composition see tab. 1). Parallel lamination within limestone beds is not so apparent. This structure indicates an undisturbed deposition below the wave base. The general character of the fauna (cephalopods and ostracods predominate) corresponds to pelagic environment. The absence of benthic fauna suggests anoxic conditions near the sea bottom. Limestones of this type could be classified as SMF 3 which corresponds to the Facies Belt 3 of Wilson (1975) (= basin margin or deep shelf margin, depth several tens to several hundreds of metres). There is a thick accumulation of coarse-grained bioclastic (crinoidal and cephalopod) limestones at the base of the Lochkov Formation, the section continues higher with fine-grained bioclastic Kosoř Limestone with cherts (litological composition see tab. 1). Both types of limestones are unsorted, bioclasts are not rounded or poorly rounded. These limestones could be classified as SMF 5 (alternatively SMF 9) which corresponds to the Facies Belt 4 (= foreslope of carbonate platform, depth several tens of metres). Organic detritus of different kind and size from carbonate buildup was deposited there by debris flows. This section belongs to the area of deeper-water development of the Požáry and Lochkov formations (Radotín Limestone).

The third section is situated in the quarry of the former Podolí cementary plant in Praha-Podolí, nowadays the Podolí swimming pool (Fig 1.3, Fig. 2). The uppermost levels of the Požáry Formation (Přídolí Series and the lowermost levels of the Lochkovian Stage) consist of platy, dark grey micritic bituminous limestones alternating with black calcareous shale interbeds (composition see tab. 1). Parallel lamination is a typical feature within limestone beds. Inclined lamination was found in some beds, too. Fauna of these beds indicates pelagic environment – graptolites, ostracods and epiplanctonic bivalves

Tab. 1. Percentage distribution of main components in main limestone types.

Section – lithological type	micrite	sparite	bioclasts	dolomite
Radotín – micritic to biomicritic l$^{st.}$ (SMF 3)	50–60	< 5	5–10	30
Radotín – coarse-grained bioclastic l$^{st.}$ (SMF 5)	10–20	< 5	> 50	10–15
Radotín – fine-grained bioclastic l$^{st.}$ (SMF 5)	10–15	30–40	25–40	5
Podolí – micritic to biomicritic l$^{st.}$ (SMF 3)	40–50	< 5	10	5
Podolí – medium sized to coarse-grained bioclastic l$^{st.}$ (SMF 5, 9)	15–30	30	30–50	5
Požáry – medium sized to coarse-grained bioclastic l$^{st.}$ (SMF 5, 9, 12)	5	20–30	> 50	5–20

predominate. This type of limestone is possible to classify as SMF 3 of Wilson (1975) which corresponds to the Facies Belt 3 (= basin margin or deep shelf margin, depth several tens to several hundreds of metres). The accumulation of coarse-grained bioclastic limestones (crinoidal and cephalopod) of the lower part of Lochkov Formation (Lochkovian Stage) corresponds to SMF 5 (composition see tab. 1). This microfacies is characteristic for the Facies Belt 4 (= foreslope of carbonate platform, depth several tens of metres). This section represents the transitional development between the Radotín section and the section at "Požáry" quarry near Praha-Řeporyje within the Přídolí-Lochkovian boundary interval.

CONCLUSIONS

The results of microfacies analysis fit well with the shallowing trend of the sedimentary basin during the uppermost Přídolí and the lowermost Lochkovian (Chlupáč et al. 1992, Crick et al. 2001). The drop of the sea level results into an increased input of coarse detrital (mostly crinoidal) material to deeper part of sedimentary basin.

Crinoidal "forests" in the NW flank of the Barrandian area were the source of the detrital material (Chlupáč *et al.* 1992). The limestones of the "Požáry" section at Praha-Řeporyje were deposited close to this source in the area of shallow-water development of boundary beds. The deposition was strongly influenced by the waves. The Podolí and the Radotín sections were situated further basinwards, where the input of detrital (mostly crinoidal) material was more limited. Sedimentary structures show that the deposition took place in deeper-water environment below the wave-base. Such bioclastic material was transported to deeper-marine environment by traction bottom currents, coarse-grained bioclastic limestones can be classified as debris flows. The idea of the turbidite deposition in this boundary interval (Suchý *et al.* 1996) was not proved, especially in lowermost part of Lochkov Formation.

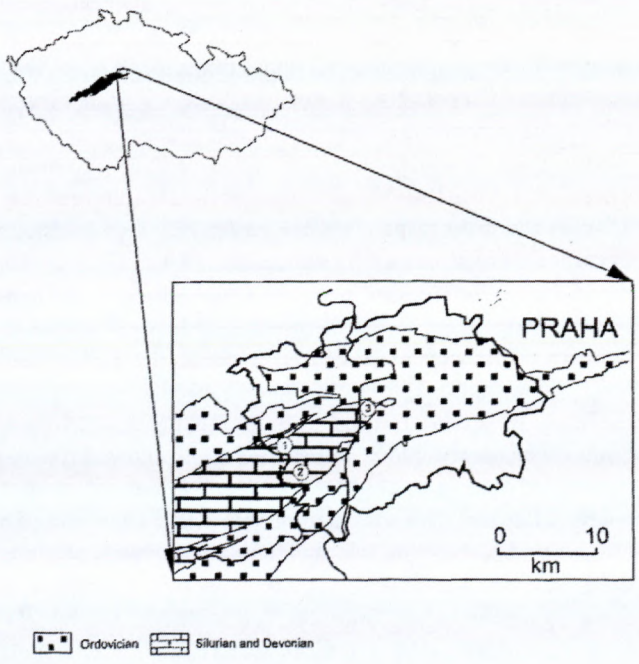


Fig. 1. The position of studied sections in the Prague Basin. 1 – the section in the "Požáry" quarry at Praha-Řeporyje, 2 – the section in Praha-Radotín, 3 – Podolí section. Modified according to Fatka (1999).

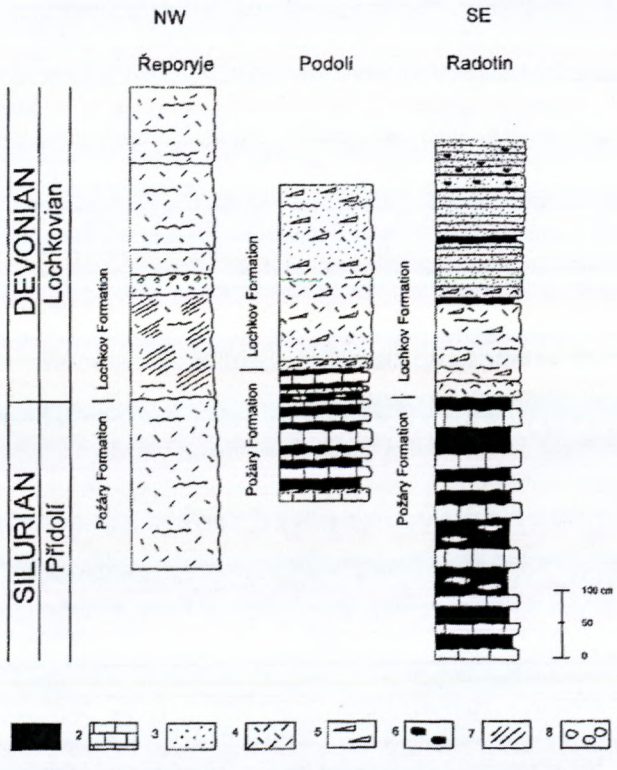


Fig. 2. Lithology of the three studied sections. The sections are arranged from shallow-water development in NW flank to deeper-water development in SE flank of the Barrandian area.
1 – dark calcareous shales, 2 – dark micritic and biomicritic limestones, 3 – fine-grained bioclastic limestones, 4 – coarse-grained bioclastic (crinoidal) limestones, 5 – cephalopod limestones, 6 – sedimentary breccia, 7 – strong dolomitization, 8 – cherts.

This research shows the possibility of application of microfacies analysis in the Early Palaeozoic carbonates of the Barrandian area.

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STRATIGRAPHIC DISTRIBUTION OF THE CLASS HYOLITHA (MOLLUSCA) IN THE BARRANDIAN AREA (CZECH REPUBLIC)

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Abstract: The distribution of species of the class Hyolitha in Middle Cambrian to Middle Devonian sediments of the Barrandian area shows unequal pattern. More than 110 species have been ascertained in this area since 1847.

INTRODUCTION

Hyoliths are usually classified as a separate class of the phylum Mollusca, and/or as an extinct phylum (Runnegar and Pojeta 1974). Two orders of the class Hyolitha – *Hyolithida* and *Orthothecida* have been distinguished (Marek 1963). Species of the order *Hyolithida* range from the Lower Cambrian to the Middle Permian, while species of the order *Orthothecida* are known from the Lower Cambrian to the Upper Permian (Marek *et al.* 1997).

In the Barrandian area hyoliths have been established to range from the Middle Cambrian to the Middle Devonian. This paper summarizes recently existing data about stratigraphic distribution of the class Hyolitha in the Barrandian area.

HISTORY OF RESEARCH OF HYOLITHS IN THE BARRANDIAN AREA

J. Barrande proposed in 1847 five hyolithid species under the generic name *Pugiunculus* Barrande, 1847 which is a junior synonym of the genus *Hyolithes* Eichwald, 1840 (Marek *et al.* 1997). In the year 1867 Barrande published the third volume of his "Système Silurien du centre de la Bohême", dealing with conulariids, hyoliths and tentaculitids.

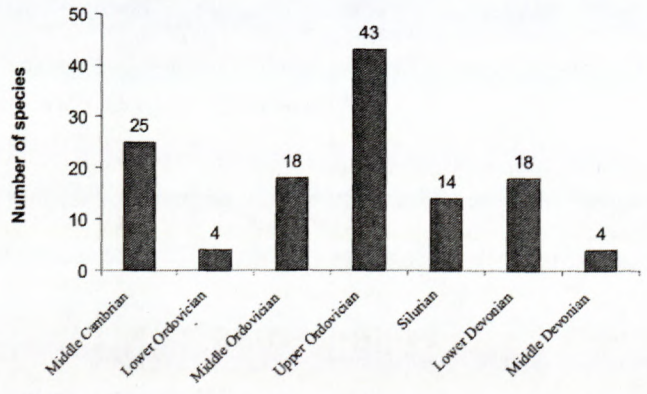


Fig. 1. Distribution of hyolith species in the Palaeozoic of the Barrandian area.

In this monograph 33 hyolithid species were described. Novák (1891) revised all the Barrande's species; 23 of them remained in use and he established other 29 new taxa.

Next monograph devoted to middle Palaeozoic hyoliths was the study published by Zázvorka (1928), who described several new species and some other species – described by Barrande (1867) and Novák (1891) – were reexamined.

After the World War Two, Chlupáč mentioned stratigraphic distribution of Devonian hyoliths in several papers (1951, 1953, 1955a, 1955b, 1957, 1959, 1960 and 1982). Havlíček and Vaněk (1966) listed stratigraphic ranges for majority of Ordovician hyolith taxa. During 1960's Marek started publishing papers focused on systematic of the class Hyolitha (Cambrian – 1972, 1975a, 1980, 1981, Ordovician – 1966, 1967, 1974, 1975b and 1989). He also published several papers on hyolith morphology (Marek 1963, Marek *et al.* 1997), biology and paleoecology (Marek 1976, Marek and Galle 1976, Marek and Yochelson 1976). Since 1960's Marek established 36 new hyolith species, 22 new genera and other 29 species revised.

Cambrian

Twelve hyolith species assigned to seven separate genera have been described from the Middle Cambrian (Jince Formation) of the Barrandian area (Fig. 2). Six hyolith species occur in the Skryje-Týřovice Area, five taxa are described from the Příbram-Jince Basin and one species is known from both areas. Four hyolith species were established by Barrande (1867) – three of them from the Skryje-Týřovice Area and one species from both areas. Novák (1891) described one species from the Skryje-Týřovice Area. Marek (different papers) established other two species from the Skryje-Týřovice Area and revised all the earlier described taxa. The detail statigraphic ranges of six hyolith species in Příbram-Jince Basin are published in Fatka *et al.* (2004).

Ordovician

In the Ordovician of the Barrandian area sixty-two species ranged to twenty-three separate hyolith genera have been described (Fig. 3). Barrande (1847, 1867) established

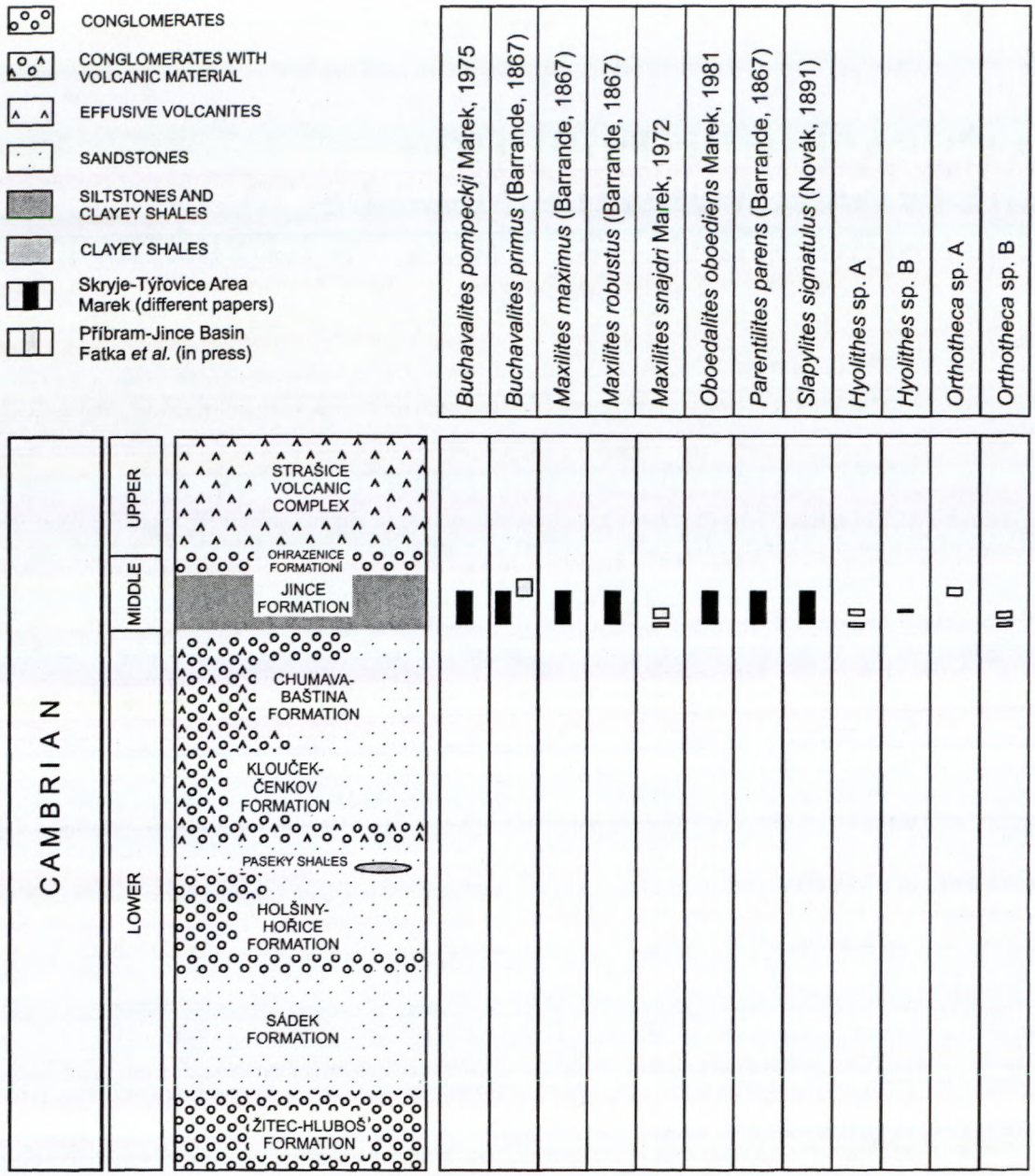


Fig. 2. Stratigraphic distribution of hyolith species in Middle Cambrian sediments of the Barrandian area.

fourteen hyolith species, Novák (1891) added ten new species and Zázvorka (1930) supplemented four other taxa. Marek (different papers) established thirty-three new hyolith species and twenty-one taxa revised.

The major part of species is known to occur in the Upper Ordovician (43 species) while the lowest number is documented from the Lower Ordovician (1 species). From sediments of the Berounian Stage (= Caradoc) forty-two species of fifteen different genera are described. The distribution of hyolith species within this time interval fits well with the paper discussing Ordovician biodiversity (Fatka *et al.* 2000).

Silurian

Fourteen species (classified in four genera) are known from the Silurian rocks (Fig. 4). Barrande (1867) described five species, Novák (1891) established next nine new species, revising one species. Marek (1975b) revised one hyolith form. Data on stratigraphic distribution of Silurian taxa are based mostly on the Novák's paper (1891).

Devonian

Twenty-two hyolith species of four different hyolith genera have been established from the Devonian rocks of the Barrandian area (Fig. 5). Barrande (1867) described twelve new hyolith species. Novák (1891) established another ten new hyolith taxa. Marek and Galle (1976) revised two hyolith species. Their stratigraphic ranges are based in general only on the Chlupáč's data (1951, 1953, 1955a, 1955b, 1957, 1959, 1960 and 1982).

CONCLUSIONS

Recently more than 110 hyolith species are known from the Barrandian area (Fig. 1). It is necessary to established new Cambrian species (Fatka 2000, Fatka – personal

communication), propose several new Lower Ordovician taxa (Kraft and Fatka – personal communication), and revised all Silurian and Devonian species (Chlupáč – personal communication). Furthermore it is necessary to revise systematic and stratigraphic data of Cambrian and especially Silurian and Devonian species where almost only the formal genera *Hyolithes* and *Orthotheca*, have been used.

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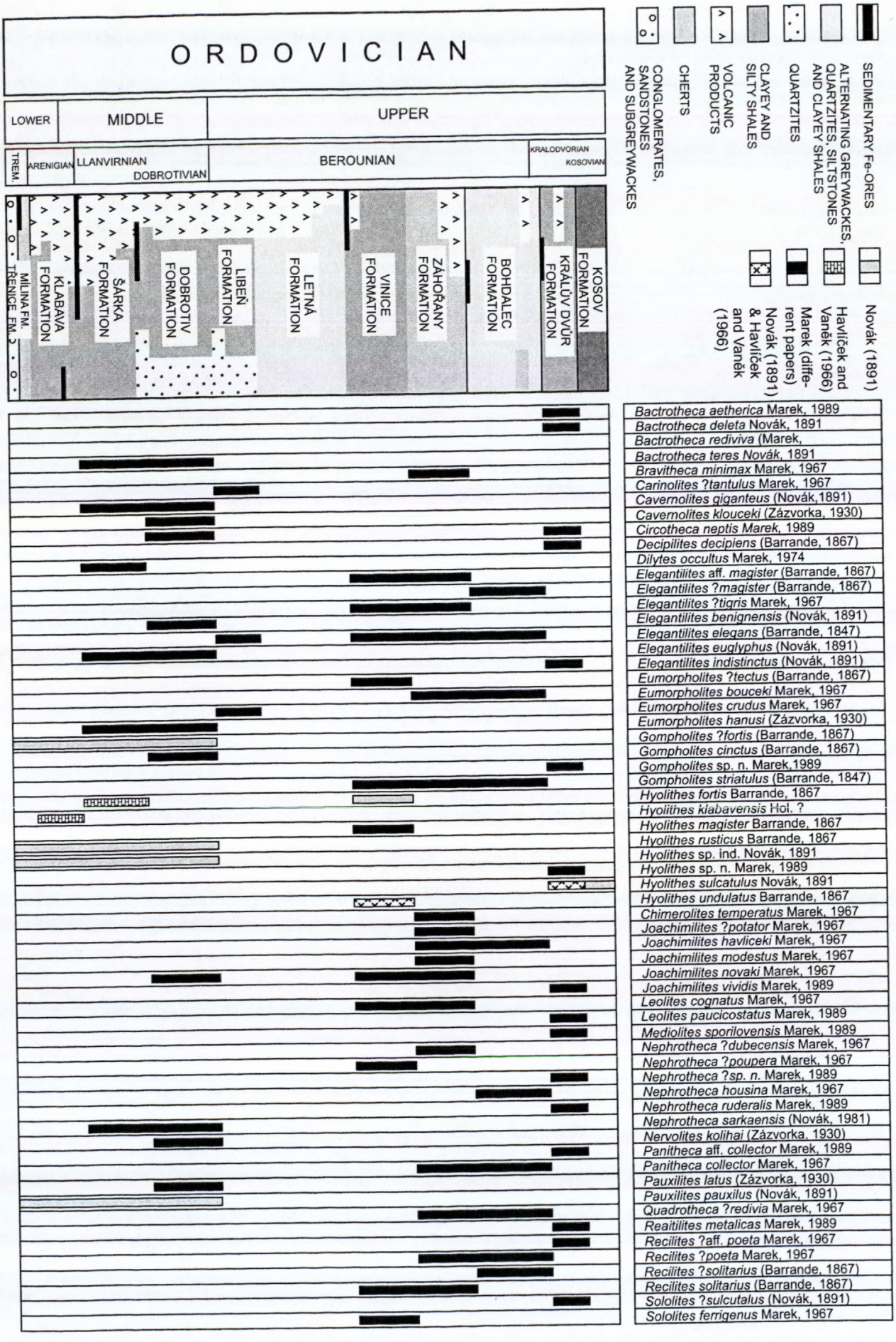
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Bactrotheca deleta Novák, 1891
Bactrotheca rediviva (Marek,
Bactrotheca teres Novák, 1891
Bravitheca minimax Marek, 1967
Carinolites ?tantulus Marek, 1967
Cavernolites giganteus (Novák,1891)
Cavernolites klouceki (Zázvorka, 1930)
Circotheca neptis Marek, 1989
Decipilites decipiens (Barrande, 1867)
Dilytes occultus Marek, 1974
Elegantilites aff. *magister* (Barrande, 1867)
Elegantilites ?magister (Barrande, 1867)
Elegantilites ?tigris Marek, 1967
Elegantilites benignensis (Novák, 1891)
Elegantilites elegans (Barrande, 1847)
Elegantilites euglyphus (Novák, 1891)
Elegantilites indistinctus (Novák, 1891)
Eumorpholites ?tectus (Barrande, 1867)
Eumorpholites bouceki Marek, 1967
Eumorpholites crudus Marek, 1967
Eumorpholites hanusi (Zázvorka, 1930)
Gompholites ?fortis (Barrande, 1867)
Gompholites cinctus (Barrande, 1867)
Gompholites sp. n. Marek,1989
Gompholites striatulus (Barrande, 1847)
Hyolithes fortis Barrande, 1867
Hyolithes klabavensis Hol. ?
Hyolithes magister Barrande, 1867
Hyolithes rusticus Barrande, 1867
Hyolithes sp. ind. Novák, 1891
Hyolithes sp. n. Marek, 1989
Hyolithes sulcatulus Novák, 1891
Hyolithes undulatus Barrande, 1867
Chimerolites temperatus Marek, 1967
Joachimilites ?potator Marek, 1967
Joachimilites havliceki Marek, 1967
Joachimilites modestus Marek, 1967
Joachimilites novaki Marek, 1967
Joachimilites vividis Marek, 1989
Leolites cognatus Marek, 1967
Leolites paucicostatus Marek, 1989
Mediolites sporilovensis Marek, 1989
Nephrotheca ?dubecensis Marek, 1967
Nephrotheca ?poupera Marek, 1967
Nephrotheca ?sp. n. Marek, 1989
Nephrotheca housina Marek, 1967
Nephrotheca ruderalis Marek, 1989
Nephrotheca sarkaensis (Novák, 1981)
Nervolites kolihai (Zázvorka, 1930)
Panitheca aff. *collector* Marek, 1989
Panitheca collector Marek, 1967
Pauxilites latus (Zázvorka, 1930)
Pauxilites pauxilus (Novák, 1891)
Quadrotheca ?redivia Marek, 1967
Reaitilites metalicas Marek, 1989
Recilites ?aff. poeta Marek, 1967
Recilites ?poeta Marek, 1967
Recilites ?solitarius (Barrande, 1867)
Recilites solitarius (Barrande, 1867)
Sololites ?sulcutalus (Novák, 1891)
Sololites ferrigenus Marek, 1967

Fig. 3. Stratigraphic distribution of hyolith species in Ordorician sediments of the Barrandian area.

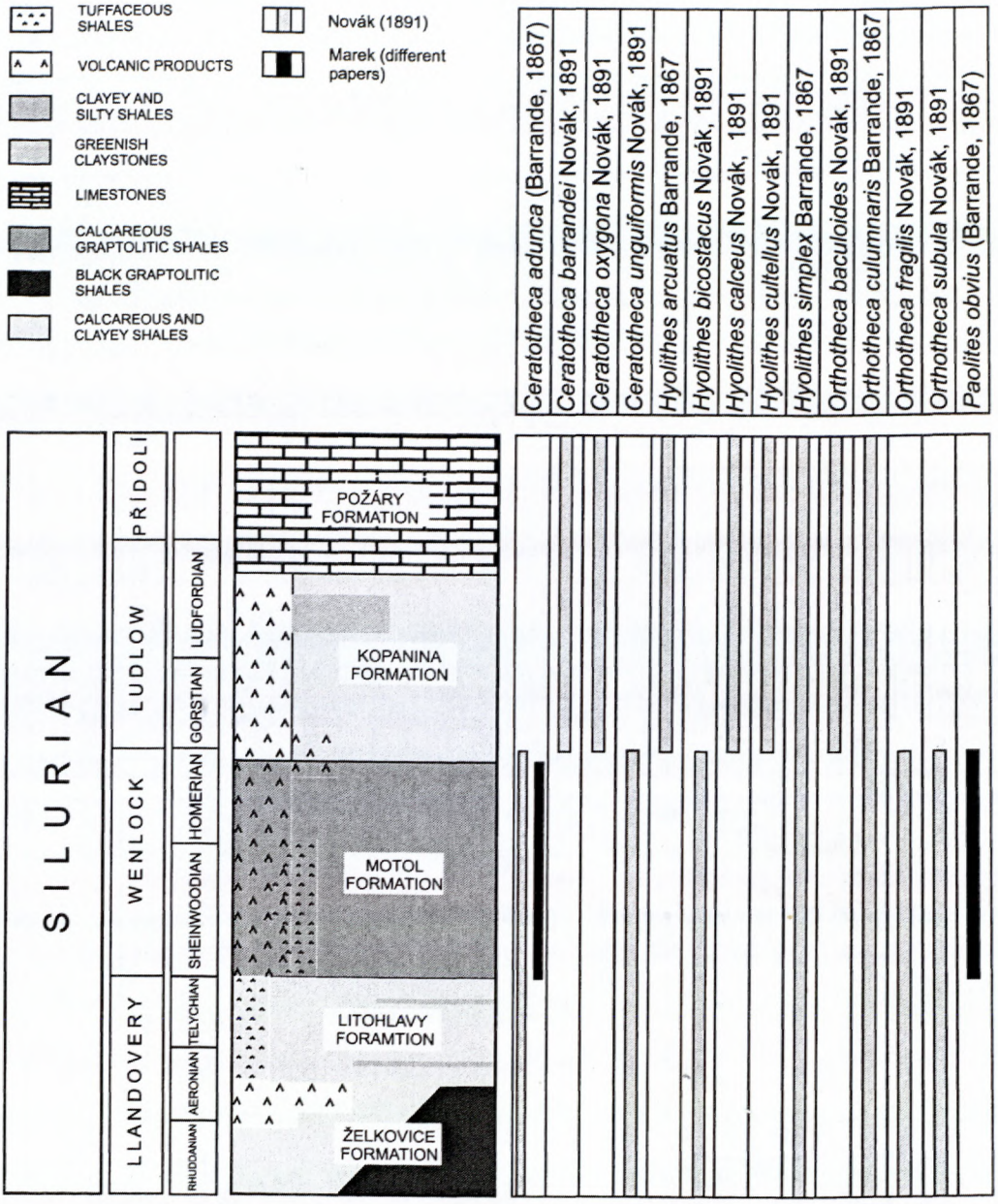


Fig. 4. Stratigraphic distribution of hyolith species in Silurian sediments of the Barrandian area.

Fig. 5. Stratigraphic distribution of hyolith species in Devonian sediments of the Barrandian area.

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BALTICA-RELATED ACRITARCHS FROM SOUTHERN MORAVIA (EARLY CAMBRIAN)

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Abstract: Diversified assemblages of acid-resistant plant microfossils (acritarchs, prasinophytes and algal/cyanobacterial filaments) have been obtained from the so-called "Basal clastic Series" or "Devonian basal clastics". Basal clastics are predominantly coarse-grained sediments which form the lowermost portion of the Palaeozoic clastic cover of the Brunovistulicum. Excellent preservation of recovered specimens, a high density of accumulations of palynomorphs in investigated rock samples, a lack of thermal alteration of a polymeric vesicle wall (TAI about 1+) and common imprints of crystals of pyrite document the autochthonous origin of acritarch associations. Palynomorphs obtained from the three deep boreholes (Měnín-1, Němčičky-3 and Němčičky-6) represent a reliable evidence of the late Early Cambrian age (*Holmia kjerulfi – Protolenus* faunal zones) of fine-grained interlayers within the predominantly coarse-grained sequences as well as their marine origin. New investigation of samples from Měnín-1 borehole (depth 1565–1566 m) extends the age of the marine ingression in southern Moravia to the lowermost Cambrian (palynozone *Asteridium tornatum – Comasphaeridium velvetum*) Moreover, assemblages of fossil marine microplankton from southern Moravia may elucidate as yet not resolved problems of palaeogeography and of the provenance of terranes accumulated near the Baltica/Gondwana suture (Trans-European Suture Zone).

INTRODUCTION

An affiliation of the Brunovistulicum to major palaeogeographic units and its position within the Trans-European Baltica-Gondwana suture is as yet enigmatic (D. Franke 1995). The Palaeozoic clastic cover of the Brunovistulicum is largely concealed under the northern part of the Carpathian flysh belt in the eastern part and under the SE branch of the Variscide mobile belt in its middle part (Fig. 1). According to Franke (1999), all areas SE of the Bohemian Massif, along the eastern margin of Variscides, are too strongly reworked and displaced during the Alpine orogen to offer any clues for the terrane analysis. The southern flank of Variscides (Iberia, France) is according to Franke better disposed for an assessment of the palaeogeography of individual terranes. However, despite the deep burial of analysed samples, exceeding five kilometres in Němčičky-3 and Němčičky-6 boreholes, sequences underlaying the orogenic belts are apparently sufficiently unharmed to contain well preserved and abundant palynomorphs. These may provide useful data for biogeographic considerations (Servais and Fatka 1997).

GEOLOGY

Basal clastics consist of predominantly terrigenous deposits in which petromictic conglometrates and subarcoses with abundant feldspatic detritus (the "lower inmature member" of Skoček 1980) pass upwards into mature quartzose sandstones, alternating with micaceous, dark grey siltstones and rare clayey shales. The succession is marked by a cyclic sedimentation with common fining upwards cycles, by a prevalent violet, brown or reddish colour and by frequent lateral and vertical transitions of individual lithological types (Dvořák 1978, 1998, Zádrapa and Skoček 1983). Most complete recovery of basal clastics has been obtained in the Měnín 1 borehole, in which the total thickness of the unmetamorphosed deposits underlaying Givetian carbonates exceeds 1600 m. An untypical thick layer of light grey to aquamarine clayey shales (37 m thick) is developed between the lower inmature member and the middle part of the succession, formed by mature sandstones (Dvořák 1968).

Apart from acritarchs, ichnofossils and microscopic and megascopic algal threads, basal clastics are devoid of a palaeontological evidence. A deposition in hot, arid climate has been proposed for the unsorted feldspatic, unmature sediments (aeolian and fluvial), while aquamarine claystones have been presumably deposited in ephemeral lakes (Skoček 1980). Consequently, basal clastic have been interpreted as an equivalent of the British Old Red Sandstone (Skoček 1980, Dvořák 1998).

Analogical petromictic conglomerates have been classified as tillites (Kowalski 1983) in Upper Silesia. Light grey bioturbated quartzose sandstones were interpreted as tidal arenites.

Bioturbated sandstones from the Měnín-1 borehole propted Roth (1981) to suggest an analogy of clastics from southern Moravia with subsurface strata in southern Poland (Goczalkowice IG-1 borehole, Upper Silesia) in which similarly developed thick strata of bioturbated sandstones (*Skolithos* Sandstone Member, Bioturbated Sandstone Member) underlay sediments with well documented Early Cambrian age. Roth predicted an essential role of palynology in a discrimination of Cambrian and Devonian clastics. The recent investigation confirmed the validity of Roth's conclusions.

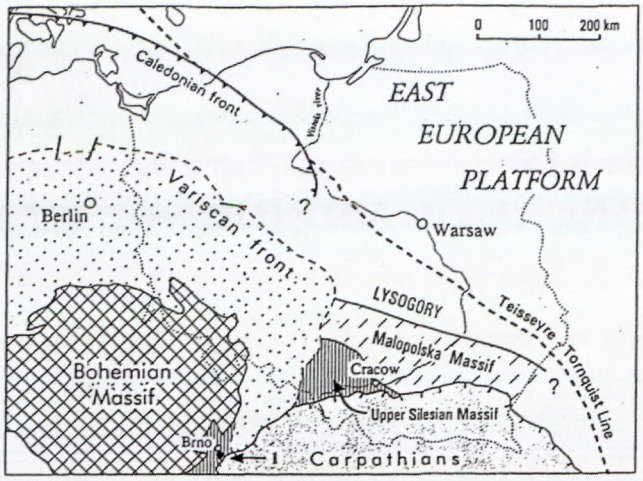


Fig. 1. Simplified structural map of central Europe showing the crustal units in the Variscan foreland of southern Poland. Dotted line indicates the Polish border. From Belka *et al.* (2000, Fig. 1).
1 – the position of the Měnín-1 borehole (15 km SSE from Brno).

PALYNOLOGY

Samples from the three deep boreholes Měnín-1 (Fatka and Vavrdová, 1998), Němčičky-3 (Jachowicz and Přichystal 1997, Vavrdová and Bek 2001), and Němčičky-6 (Vavrdová 1997b) yielded numerous, unaltered microfossils. Altogether, 26 genera (one of them new) and 55 species have been identified in the late Early Cambrian of southern Moravia (Vavrdová – Bek 2001). Palynomorphs have been studied in thin sections, palynological slides and in SEM observation (plate I). Acanthomorphic acritarchs, namely genera *Asteridium, Heliodinium* and *Skiagia* dominate in the associations from silty samples, while clayey shales in the Měnín-1 borehole yielded different spectra with dominant *Archaeodiscina umbonulata* Volkova 1968 *Tasmanites volkovae* Kirjanov 1974, *Leiosphaeridia* sp. and various leiospheres. Ascertained acritarchs indicate the *Holmia kjerulfi* to *Protolenus* faunal zones of the Early Cambrian age for the sample from the Měnín-1 borehole (depth 473–477.5 m), and *Liepaina plana – Volkovia dentifera* palynozone (up to *Acadoparadoxides oelandicus* Biozone) for the sample from the Němčičky-3 borehole (depth 5396 m). New investigation in the Měnín-1 borehole revealed a presence of rare, but well preserved acritarchs in the light grey, bioturbated quartzose sandstones from the depth 1565 – 1566 m, approximately 1km below the sample analyzed by Fatka and Vavrdová (1998).

Species *Asteridium tornatum* (Volkova) Moczydlowska 1991, *Comasphaeridium agglutinatum* Moczydlowska 1988, *Comasphaeridium* aff. *velvetum* Moczydlowska 1988, *Lophosphaeridium tentativum* Volkova 1968, *Lophosphaeridium* spp., *Tasmanites* aff. *tenellus* Volkova 1968, small leiospheres in tightly appressed clusters, and very thin filaments (diameter about 1 micrometre) have been preliminarily identified. Species *Asteridium tornatum* dominate in the association, together with abundant particulate organic matter. Not uncommon are organic remains assigned preliminarily to *Ceratophyton vernicosum* Kirjanov. Recovered assemblage belongs most probably to the lowermost Cambrian Asteridium tornatum – Comasphaeridium velvetum Assemblage Zone, defined by Moczydlowska (1991) in southeastern Poland (approximately Platysolenites antiquissimus faunal zone, corresponding to the uppermost Rovno and Lontova stages in the former U.S.S.R). Lowermost Cambrian assemblages differ in a substantially lower density and lower diversity from the late Early Cambrian acritarch spectra.

Light to bright yellow colour of vesicle wall of all ascertained palynomorphs indicate a very low degree of thermal alteration (not exceeding 60 °C). Apart from slight flattening and abundant imprints of pyrite crystals, recovered specimens are not deformed. Ribbon-like uniseriate filaments, often filled with crystals of pyrite (diameter ranges from several micrometres to several mm) occur as single filaments (in all investigated samples, Pl. 1, fig. 3) or in clusters of several to several hundreds of specimens (Němčičky 6 borehole, depth 5157.8 m). Assemblages obtained in southern Moravia are closely similar to coeval marine microplankton described from the subsurface sequences of the East European platform (E Poland, Lublin slope; Ukraina, Latvia, Bothnian sea) and Baltoscandia (S Sweden, S Norvay, Denmark Bornholm) Abundant algal/cyanobacterial threads are characteristic for the assemblages from sub-glacial area (Moczydlowska and Vidal 1995).

DISCUSSION

Various ways of the termination of Variscides (Dvořák 1968) and various positions of the Gondwana/Baltica sutures have been proposed (for references, see Belka *et al.* 2000). The Brunovistulicum has been taken as an integral part of the Eastern European Platform (Cháb and Suk, 1976, Vidal and Moczydlowska 1995, Servais and Fatka 1997).

Peri-Gondwanan linkages of Upper Silesia, Malopolska and Lysogory blocks have been suggested by Belka *et al.*, (2000), based on K–Ar ages of detrital muscovite grains as well as on some biogeographic evidence (ichnofossils and brachiopods). Unequivocal significance of the 600 Ma old zircons, present on both sides of TESZ is discussed by Valverde-Vaquero *et al.* (2000).

Moczydlowska (1998) assigned the Upper Silesia to the marginal part of Avalonia, neighbouring Iberia.

Acritarchs may solve the provenance of terranes in time interval for which a pattern of biogeographic differenciation of fossil marine microplakton, has been established (Servais and Katzung 1993, Servais 1994). The provincialism in the distribution of acritarch assemblages of the Early Cambrian age is not sufficiently documented in the fossil record (Moczydlowska and Vidal 1992, Moczydlowska 1998). However, the latitudinal differentiation of acritarch assemblages is well documented in the Early Ordovician time interval (Tongiorgi *et al.* 1994, Servais and Fatka 1997).

Acritarch assemblages of the Early Ordovician age known from Avalonia, Perunica, Armorica and other Perigondwanan terranes are distinguished by a presence of high-latitude acritarch associations, defined as *Coryphidium bohemicum* acritarch bioprovince (Vavrdová 1997b) or as *Arbusculidium – Coryphidium – Striatotheca* Bioprovince (Li Jun 1987).

High latitude, cold water acritarch assemblages are markedly different from the acritarchs of the Early Ordovician age, described by Jachowicz (in Bula and Jachowicz 1992) from the northern part of Upper Silesia (BM-152 borehole, Bibiela), where associations of genera *Baltisphaeridium*, *Ordovicidium*, *Peteinosphaeridium*, *Veryhachium* and *Polygonium* clearly show their Baltic affinity.

The composite terrane of Avalonia (Newfoundland, southern England, Belgium, western Germany) together with Armorica, Iberia and Perunica (Saxothuringia and Barrandian) drifted to high southern latitudes in Arenig (Cocks and Fortey 1995). On the other hand, Brunovistulicum, similarly as other Baltica-related terranes drifted evidently in the opposite direction, from subpolar position in the Early Cambrian to subtropical paleolatitudes in the Early Ordovician. The drift is well documented both in the microfloristic data and in the lithological development (Arenigian carbonates, Llanvirnian oolitic limestones). Apparently, an assignment of Brunovistulicum to Avalonia cannot be corroborated.

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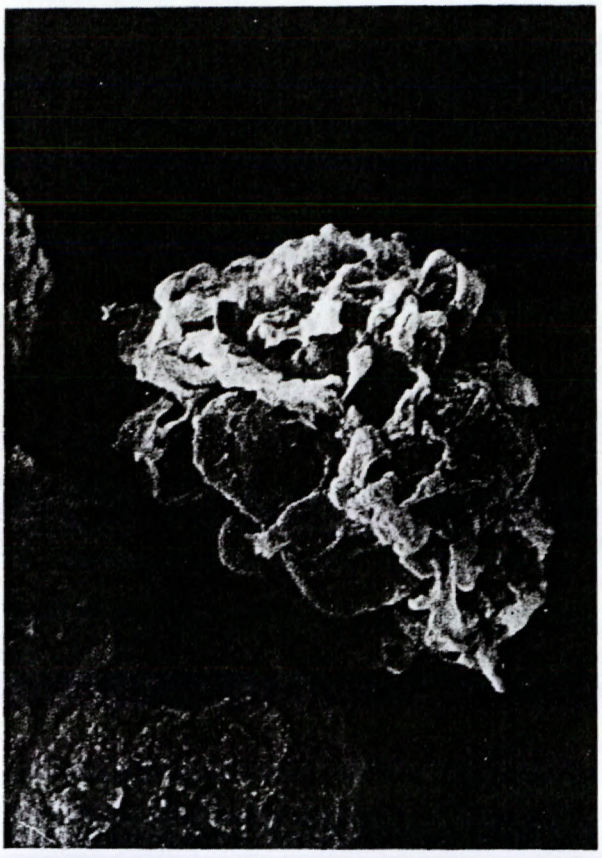
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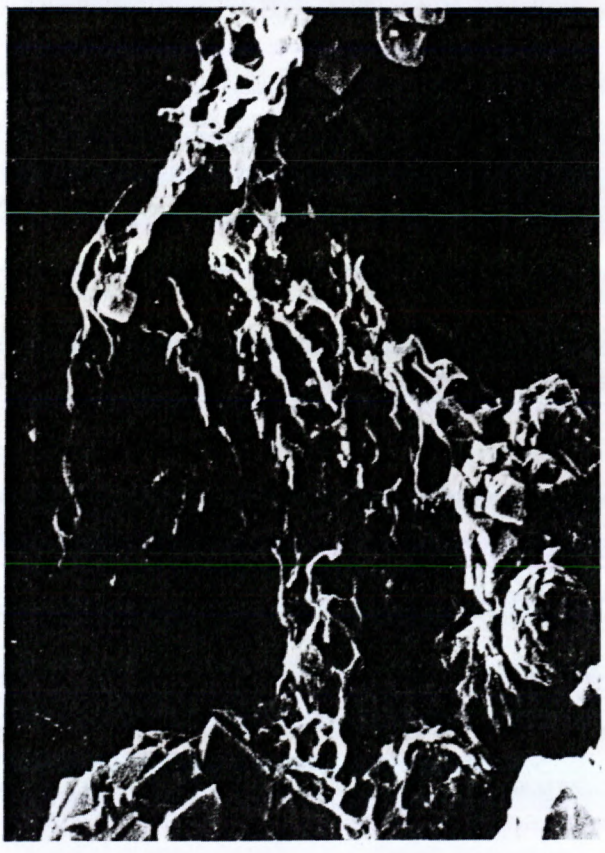


Plate 1

All specimen are obtained from the sample from the Němčičky-3 borehole, depth 5396 m and stored in Geological Institute AS CR, Prague.

Photos by Ing. A. Langrová and RNDr Z. Korbelová

1 – *Skiagia* sp. indet.; vesicle deformed by crystals of pyrite. Specimen No. MV 1728, x2500,

2 – *Skiagia* sp. Indet.; vesicle filled and deformed by pyrite. Specimen No. MV 1727, x3000,

3 – Filamentous structures filled with pyrite B6, No. MV 1721. x3000,

4 – *Sagatum priscum* (Volkova) Vavrdová and Bek 2001. Torned outer reticulate layer. Specimen No. MV 1188, x2500.

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SEDIMENTOLOGY OF THE LOCHKOVIAN–PRAGIAN BOUNDARY INTERVAL IN THE LOWER DEVONIAN OF THE BARRANDIAN AREA (CZECH REPUBLIC)

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Abstract: In paper the sedimentology of the Lower Devonian of Barrandian area is described with the focus on the Lochkovian–Pragian boundary interval. This research has been carried out on three localities (Černá rokle near Kosoř, Homolka near Praha-Velká Chuchle, Cikánka near Praha-Slivenec) in SW part of Prague. The section at Velká Chuchle is an international stratotype of the Lochkovian–Pragian boundary and remaining two localities are its parastratotypes. These three sections show varied carbonate facies development (from shallow water to deep water) and thus studied localities provide good informational basis for sedimentological interpretation, especially with respect to sedimentary structures and other features. This work deals in detail with the theory of turbidity current deposition and so-called Lochkovian–Pragian boundary Event is described in terms of sequence stratigraphy. The character of this event is associated with turbidite regime and with the distribution of particular carbonate facies in the Lower Devonian of the Barrandian area.

INTRODUCTION

This paper is focused on the sedimentology of the Lochkovian–Pragian boundary interval in the Lower Devonian of the Barandian area. The research of this boundary is important mainly for two reasons: it represents the boundary standards of stages, which have internationaly accepted stratotype in the Barrandian area (Chlupáč, Oliver 1989). It is also interesting from the sedimentological point of view, because the effect of the Lochkovian – Pragian boundary Event can be observed here. This event (according to Chlupáč, Kukal 1986, 1988) can be correlated with other regions and continents.

The purpose of this paper is to contribute to the modern sedimentological research of the Barrandian Palaeozoic and to reconstruct the sedimentary conditions of rocks along this stratotype and reference localites. This boundary was studied in the past mainly from the biostratigraphical and palaeontological points of view (especially Chlupáč *et al.* 1985), however, its modern sedimentological characteristics have not yet been presented.

For this research three sections in the SW part of Prague (Fig. 1) have been chosen, reflecting different, especially carbonate facies development of the boundary interval and showing a good correlation of biostratigraphical and lithological data. One of them (Homolka near Velká Chuchle) is the international stratotype of the boundary itself and the other two sections (Černá rokle near Kosoř and Cikánka near Praha-Slivenec) are important parastratotypes (Chlupáč *et al.* 1985). From the viewpoint of the marine sedimentary environment, the section of Černá rokle near Kosoř represents the deepest water facies development, on the other hand the old quarries at Cikánka represent the shallow water development. The section at Velká Chuchle is reflecting a transition between both facies (Chlupáč *et al.* 1992, 1998). All three localities have been visited many times by representatives of international organizations from the 50's, mainly concerning the Silurian–Devonian boundary and the boundaries of the Lower Devonian stages (f. ex. Svoboda *ed.* 1960, McLaren 1977, Ziegler and Klapper 1982, 1985, Chlupáč and Oliver 1989, Chlupáč 2000 a, b, etc.). In this paper, the definitions of individual litostratigraphic units (Chlupáč *ed.* 1968) are used (formations, members, facies).

Černá rokle near Kosoř

The outcrops of the Lower Devonian sediments at Černá rokle are situated in the SE of the village Kosoř, on the SW edge of Prague (Radotín) in the valley of the Šachetský stream. The studied outcrop is located at the NW slope of the valley.

From the lithological point of view, the Upper Lochkovian is developed in the facies of the Radotín Limestone. The Pragian Stage is represented by the Dvorce-Prokop Limestone. This means that Lochkov Formation is formed of dark grey platy, mainly microsparitic limestones, which regulary alternate (in intervals of 10–30 cm) with dark brownish weathered calcareous shales (Pl. 1, fig. 3).

The boundary of the Lochkov–Praha and formations in this section is situated between layers No. 80 and 81 (in the shale interbed No. 80 / 81, Fig. 2, Chlupáč *et al.* 1985), and is easily recognizable by the lithological change. The boundary between the Lochkovian and Pragian stages is a little lower (approximatelly in the layer No. 77), according to the first occurrence of the conodont *Eognathodus sulcatus sulcatus* (Weddige 1987), which, however, is not very abundant here.

The base of the Praha Formation starts with lighter grey platy micritic limestones with thin interbeds of grey and greenish brown calcareous shales. Characteristic nodular structures of the Dvorce-Prokop Limestone are well

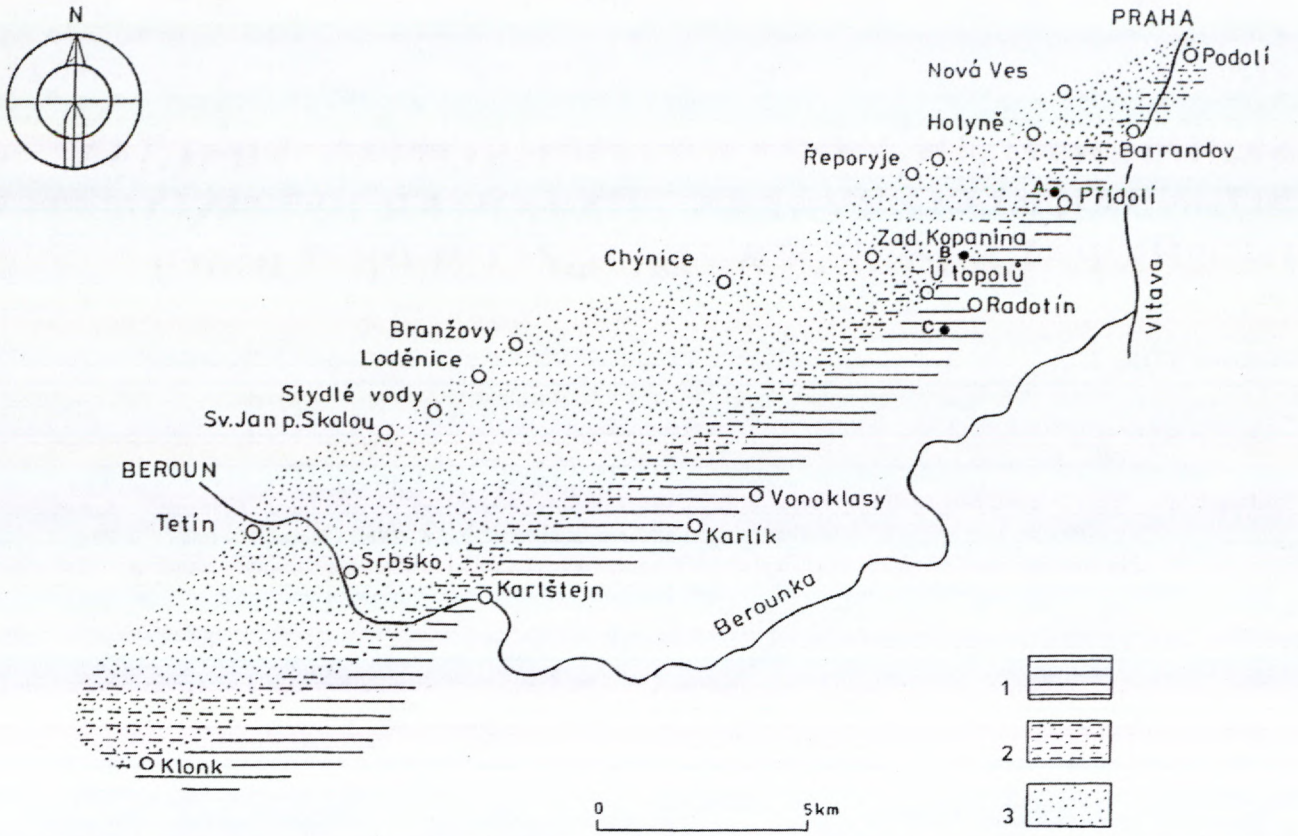


Fig. 1. Distribution of marine carbonate facies at the Lochkovian– Pragian boundary interval (the uppermost Lochkovian – basal Pragian). Black points show localities include in this paper. A – Homolka near Praha-Velká Chuchle, international stratotype of the Lochkovian–Pragian boundary, B – Cikánka near Praha-Slivenec, C – Černá rokle near Kosoř. Legend to facies: 1 – deep water (basinal) facies (the Radotín Limestone with overlying Dvorce-Prokop limestone), 2 – transitional-intermediate facies (the Kosoř Limestone with overlying Slivenec Limestone), 3 – shallow water facies (the Kotýs Limestone with overlying Koněprusy and Slivenec Limestones). Adapted according to facial maps in Chlupáč *et al.* (1992, 1998).

preserved in the thick bank of clayey micritic limestones No. 87., and higher up in the section. In comparison with the underlying Lochkov Formation, the limestones of the Praha Formation contain abundant "*Chondrites*" *burrows (ichnofossils) and are distinctly more micritic (fine-grained) and markedly lighter.*

Homolka near Praha-Velká Chuchle

The boundary layers of the Lochkovian–Pragian stages are well exposed on the northern slope of the valley between the villages of Velká Chuchle and Slivenec, in the SW part of Prague. The outcrop is situated in the old quarry at the edge of the Homolka hill, close to the street V Dolích. Since 1989, this section has been accepted as the international stratotype of the Lochkovian–Pragian boundary (Chlupáč and Oliver 1989). The sequence is more tectonically affected than at the other localities. The particular bedding planes are often subsequently tectonized.

From the lithological point of view, the Upper Lochkovian is developed in the facies of the bioclastic Radotín Limestone and in the facies of the Kosoř Limestone close to the studied boundary. The Pragian Stage is represented by the facies of the Dvorce-Prokop Limestone.

The Lochkov Formation is formed by grey, mainly biosparitic platy limestones with subordinate interbeds of dark calcareous shales. In the uppermost few metres, the light grey, coarse biosparitic limestones of Kosoř type are dominant. In some beds dark cherts are present. In comparison with the limestones at Černá rokle near Kosoř, the limestones contain markedly higher amount of organic detritus. The colour of limestones is overall lighter.

The Lochkovian–Pragian boundary (Fig. 3) is set on the base of the bed No. 12 (Chlupáč, Oliver 1989), according to the first occurrence of the conodont *Eognathodus sulcatus sulcatus* (Weddige 1987). The lowest part of Pragian stage shows an increasing amount of bioclastic material and the light grey biosparitic limestones dominate. Higher in the sequence (approximately from the bed No. 15 upward) the increase of micritic matrix can be observed, and finally, also the transition to massive beds of the typical light grey micritic Dvorce-Prokop Limestone. The studied sequence here as well as on other two sections ends with this type of limestones.

Cikánka near Praha-Slivenec

The Lochkovian–Pragian boundary interval is exposed on the left part of the old quarry "Ve skále", approximately two kilometres to the SW of Praha-Slivenec. The locality itself is a part of an active quarry, but there is no exploitation directly at the locality. The old quarry "Ve skále" is known as the most typical locality of the Slivenec Limestone and serves as an important reference section of the Lochkovian–Pragian boundary (Chlupáč *et al.* 1985).

Lithologically, the Lochkovian Stage in lower parts is developed in the transitional facies between the Radotín and Kotýs limestones, i. e. in the form of the Kosoř Limestone.

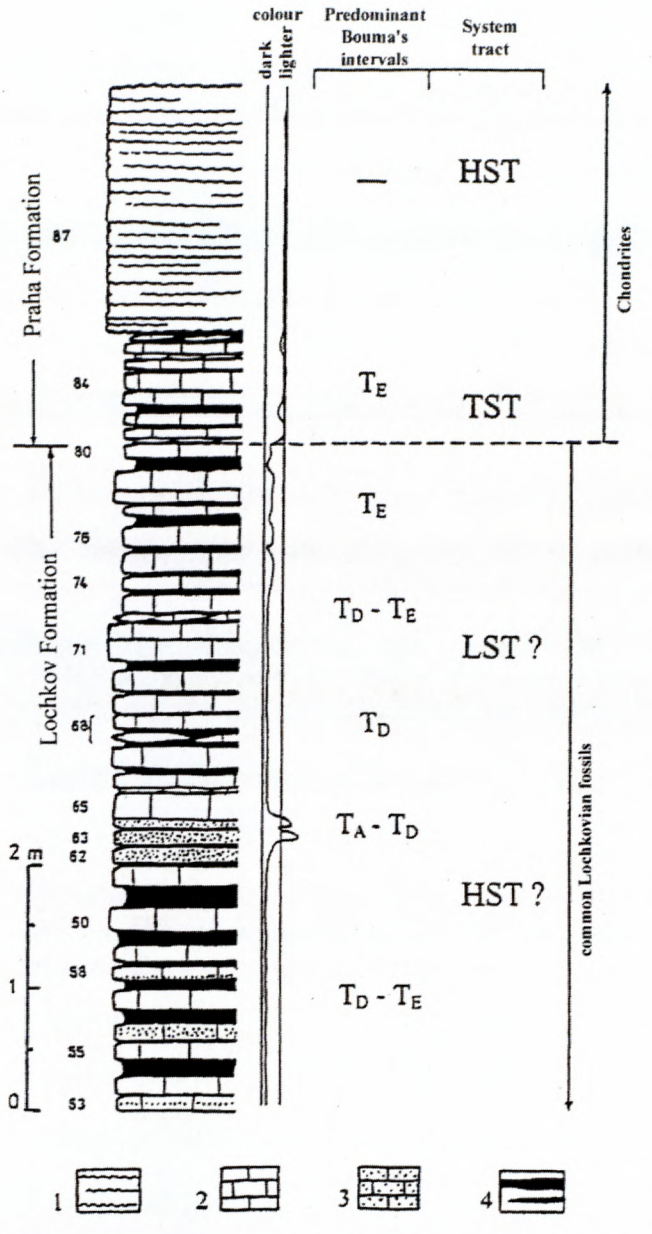


Fig. 2. Černá rokle near Kosoř: Section of the Lochkovian–Pragian boundary interval. 1 – grey micritic limestones; 2 – dark grey and grey microsparitic limestones; 3 – lighter sparitic limestones; 4 – calcareous shales. LST – lowstand system tract; TST – transgressive system tract; HST – highstand system tract (drawing from Chlupáč *et al.* 1985, adapted).

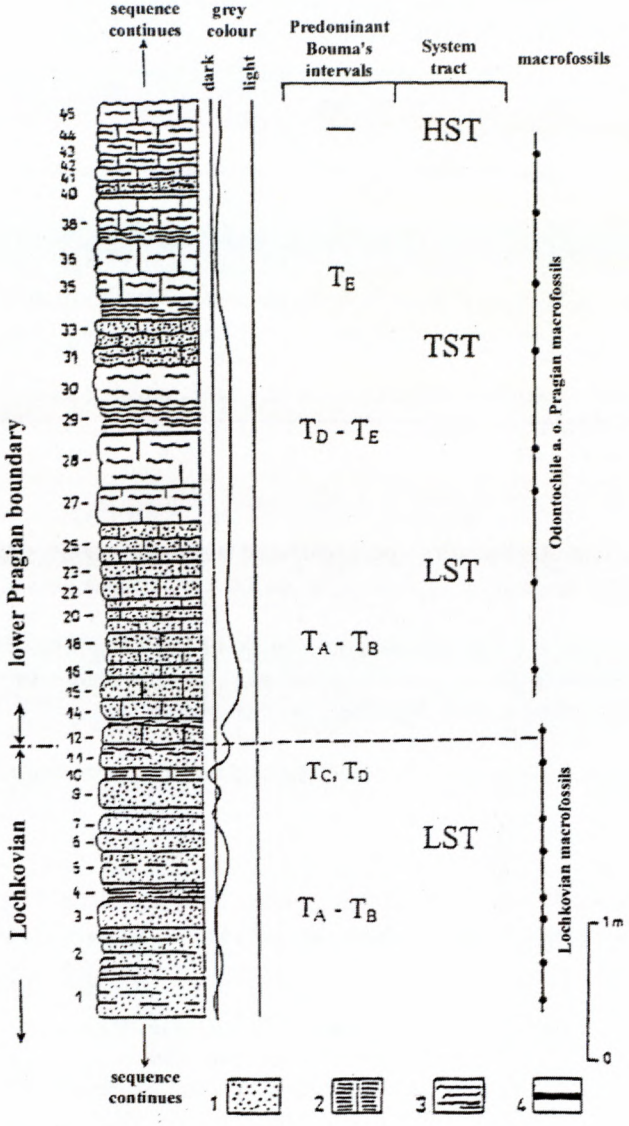


Fig. 3. Homolka near Velká Chuchle: Section representing the Lochkovian–Pragian boundary stratotype. 1 – fine-grained biodetritic to biomicritic limestones; 2 – laminated micritic limestones; 3 – nodular micritic limestones; 4 – calcareous shale interbeds. LST – lowstand system tract; TST – transgressive system tract; HST – highstand system tract (drawing from Chlupáč and Oliver 1989, adapted).

In the upper part – close to the boundary with the Pragian – also the facies of the Kotýs Limestone is present. The Pragian Stage starts with the Slivenec Limestone, which higher in the section passes into the Řeporyje Limestone, and later to the Dvorce-Prokop Limestone.

The Lochkov Formation is mainly formed by fine to corse-grained biosparitic, grey to light grey limestones with subordinate intercalations of calcareous shales. Close to the boundary with Pragian, however, the change and increase of bioclastic material is observed and the facies of the Kotýs Limestone is developed. These uppermost layers of the Lochkov Formation are generally more light and they are even more coarser-grained and better sorted than the underlying Kosoř Limestone. Cherts are not present.

The boundary between the Lochkovian and Pragian Stages (Fig. 4) is situated inside the bed No. 11, the lower part of which keeps the grey colour and the Lochkovian fauna, whereas its top part contains Pragian fauna. The colour here is lighter and sometimes reddish (Chlupáč *et al.* 1985). The lowest part of the Pragian Stage is developed as reddish, coarse bioclastic (crinoidal) Slivenec Limestone, which higher up in the section, due to the increase of micritic components and decrease of coarse organic detritus, passes into the red-brown micritic Řeporyje Limestone. The Pragian sequence ends with lithologicaly similar, but grey and nodular Dvorce-Prokop Limestone.

For the sedimentological characteristics and assessment of an origin of particular facies, however, also the structural features are important, which can be observed within individual layers.

THE SEDIMENTARY STRUCTURES OF THE LOCHKOVIAN–PRAGIAN BOUNDARY INTERVAL

Černá rokle near Kosoř

The fining upward is one of the typical structure of the Radotín Limestone of the Lochkov Formation. In some beds the coarse bioclastic fraction forms a few centimetres thick layers, which are commonly fining upwardand passing into the laminae. Laminae than alternate with mainly micritic layers. This can be observed very well, for example, within the bed No. 65. Here these couplets have thickness of about two centimetres. Sometimes the graded bedding is reflected by accumulation of coarse bioclasts, even of whole shells of brachiopods, bivalves, nautiloids etc., predominantly in the lower part of the bed (e. g. the bed No. 75).

Next type of structure of the Radotín Limestone is the common lamination – best evidenced in beds No. 49, 56, 62, 65. For example, in the bed No. 62 the lamination is formed by horizontally orientated shells of tentaculites. In the bed No. 65 the lamination is formed by about 0.5 mm thick layers of fine organic detritus and in some places this lamination is later deformed into convolution structure (Pl. 2, figs. 2a, b).

In some beds of the Radotín Limestone the bioturbation can be observed, however, it is not as frequent here as in the overlying Dvorce-Prokop Limestone of the Pragian, but it is well noticeable in the bed of laminated micrite No. 65. Here typically the ichnofossil *Zoophycos* occurs, affecting the lamination. This ichnofossil has not yet been reported from the Lochkov Formation. Its morphology is analogous with the specimens of this genus described by Chlupáč (1990) from the Dvorce-Prokop and Zlíchov limestones of the Lower Devonian of the Barrandian. On the cross section, it appears as several millimetres thick and several centimetres long linear downwards denticulated structures (Pl. 1, fig. 2).

In the Dvorce-Prokop Limestone of the Praha Formation, which is generally finer, biomicritic, the bioturbation by ichnnofossil *Chondrites* occurs. In the cross section it appears as darker grey, elliptic or tubular burrows in light grey micrite.

Distinct nodularity of the last bed at the Černá rokle section (No. 87) is noticeable. According to Kukal (1975), the nodular structure is of diagenetic origin and is limited to such limestones which contain certain defined amound of clay (approximately 15–25%).

Homolka near Velká Chuchle

The most distinctive structure of the Lochkov Formation of this stratotype locality is so-called amalgamation of particular coarser bioclastic layers into the more massive beds. For example, bed No. 7 is formed by three, several centimetres thick layers of bioclastic material, which are separated by a very thin discontinuity, obviously richer in clay and visible only on weathered bed surface. The third, latest, bioclastic pulse in this layer was the coarsest, and offers an impression of a negative graded bedding (coarsening upwards). However, there are only three individual, amalgamated and successive pulses of bioclastic material here.

Another type of structures of limestones of the Lochkov Formation in this section is the lamination, distinct mainly at

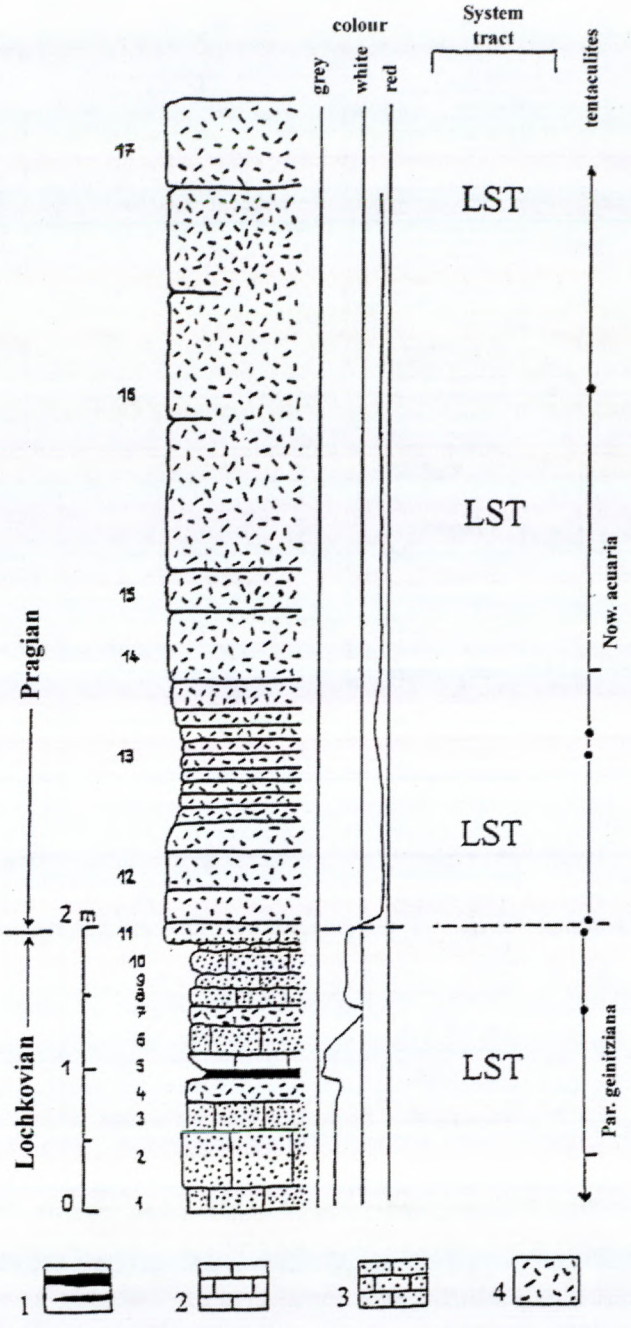


Fig. 4. Cikánka near Praha-Slivenec: Section of the Lochkovian–Pragian boundary interval. 1 – calcareous shales; 2 – dark grey and grey microsparitic limestones; 3 – lighter sparitic limestones; 4 – coarse biodetritic and sparitic limestones. LST – lowstand system tract (drawing from Chlupáč *et al.* 1985, adapted).

transitions of limestone beds into the shale interbeds (Pl. 2, fig. 1). It is formed by very thin layers of coarser bioclastic material, either in the upper, finer-grained part of the limestone bed, or already in the overlying shale interbed. Within this shale it usually gradually fades out due to the disappearing of laminae upwards.

From the standpoint of sedimentary structures, the layer of laminated micritic limestone No. 10 is noteworthy, where – as a thin section shows – the laminae are formed of positively graded thin layers of fine bioclastic material of the silt size. The laminae show sharp bases and gradually fade out towards the overlying beds into micritic matrix (similary like in the bed No. 65 in the Černá rokle section near Kosoř).

Laminae in the bed No. 10 are often deformed and uneven. Another very intresting structure of the laminite No.10 in Velká Chuchle are current ripples (Pl. 2, fig. 3), which are developed in its lowermost part. On the cross section of the bed they appear as several centimetres large lenses, elongated conformably with the lamination, with distinctly distinguishable foresets formed of coarser silt-size fraction.

The Dvorce-Prokop Limestone in the Velká Chuchle section, shows the most typical feature – the nodular structure. It is developed only in the upper part of the section. The bioturbation by ichnofossils *Chondrites* is also frequent.

Cikánka near Praha-Slivenec

Very evident structure of the Lochkov Formation, expecially in the beds of the Kotýs Limestone, but also in the beds of the underlying Kosoř Limestone, is the amalgamation of the beds. It is developed as fusing of particular bioclastic pulses into the thicker banks (Pl. 1, fig. 4). These banks are separated in places by thicker layers of shale interbeds. The beds of the Kosoř Limestone also often show – with the exception of amalgamation – the lamination and fining upward as well. This becomes evident mainly at transitions of bioclastic layers into thin shale interbeds, similarily to situation at Velká Chuchle section. The bioclastic layers become in their upper part finer and slowly pass into thin laminae, formed by coarser organic detritus in the finer clay matrix. In the uppermost part of the bed this clay matrix finally predominates and the next bioclastic pulse cuts it with erosional base (Pl. 1, fig. 4).

In the Praha Formation in the Cikánka quarry, a very distinctive amalgamation is evident again in particular layers of bioclastic, especially crinoidal, material. This gives to the Slivenec Limestone a character of massive banks – these are exploited here as the so-called Slivenec marble (Pl. 1, fig. 1). Their total thicknes is up to 12 metres. The individual banks are separated by thin, clayey laminae or films visible only on weathered surface. In some parts of the Slivenec Limestone the content of micritic matrix increases. Micrite can form also the laminated layers or lenses inside the thicker crinoidal banks. Filling of cavities of the Stromatactis type is also present (Kukal 1971).

SEDIMENTOLOGICAL INTERPRETATION

Before the interpretation it is necessary to resume the characteristic features of the individual formations in the studied sections, which might serve for the reconstruction of their sedimentary environments.

Černá rokle near Kosoř

One of frequent structures of limestones of the Lochkov Formation in Černá rokle near Kosoř (see above) is the lamination of the beds, in some places also fining upward and convolution structures. Alternation of limestone beds with calcareous shales is also typical. This trend continues up to the lower part of the Praha Formation, higher in the section the thicker micritic nodular limestones with variable content of clay predominate. From the fauna differences the deeper-water environment of shale interbeds is clear – for example the general decrease of benthic fauna and increase of planctonic and nectonic organisms (graptolites, nautiloids etc.) is very marked. On the other hand, in the limestones benthos is very common and often is enriched in redeposited shallower water organisms (frequent crinoids, trilobites, gastropodes etc.). The environment can be characterized as comparatively deepest, when relied to the other studied localities (Chlupáč *et al.* 1992, 1998). Its depth can be estimated at several hundreds of metres, maybe more. This is also evidenced by finds of the ichnofossil *Zoophycos* in the bed No. 65. Depth range of ichnofossil *Zoophycos* is indeed rather wide, according to Pek and Mikuláš (1996), nevertheles, it indicates the environment under the wave-base and it commonly occurs also in flysch turbidity sequences.

Homolka near Velká Chuchle

One of the frequent structures of the Lochkov Formation on this locality is namely the amalgamation of beds, also common lamination and fining upward, which is developed especially along the transition of limestone beds into thin shale layers. In the layer of laminated micritic limestone (No. 10), with some deformation of laminae, also the presence of current ripples on its base is important. In the Praha Formation, the trend of predominance of limestone beds over calcareous shale interbeds still continues, together with gradual increase of micritic limestone layers. In the upper part of the section also transition into thicker bedded nodular micritic banks is typical. From the paleontologic standpoint, the composition of bioclasts from Velká Chuchle is comparable with those of the Černá rokle, but the influence of redeposition (for example crinoidal fragments, brachiopods) from clearly shallow water environment (e.g., Cikánka) is obvious. The depositional environment at Velká Chuchle can be characterized as intermediate, transitional, where the depth can be estimated at one hundred of metres, slightly more or less. This is confirmed also by the composition of fauna and predominance of coarser material over of calcareous shales. Therefore, the place of deposition could not be situated far away from the source of coarse bioclastic material.

Cikánka near Praha-Slivenec

Very evident structure of the section at Cikánka is again amalgamation of individual beds into the homogenous layers. The origin of thicker banks of the Kotýs and Slivenec Limestones is also characteristic. The two limestone members show only very thin clayey covers, shortage of pelagic or nectonic fauna and the occurrence of Stromatactis textures. All these features indicate the shallow water environment. From the paleontologic, and also even lithological views these limestones show gradual transitions to the neighbouring sections, which are very similar to Velká Chuchle. Here, at the end of Lochkovian Stage, the Kotýs Limestone fade away into the Kosoř Limestone and the Slivenec Limestone of Pragian Stage gradually pass into the platy Dvorce-Prokop Limestone. The sedimentary environment along the Lochkovian–Pragian boundary interval can be interpreted here as an example of clear shallow water one. This is corroborated for example by the character of preserved fauna and by limestone structures (e.g., Stromatactis). The depth of the basin can be estimated here at several tens of metres.

If we take to consideration all the characteristics described above – i. e. structures, facies development, fauna differences, as well as assumed bathymetry and presumed basin gradient – it is possible to interpet some studied parts of sections as sediments deposited by turbidity currents. Sedimentary structures of some beds (lamination, graded bedding, current ripples etc.) very often correspond to the typical Bouma sequence (Bouma 1962).

DEPOSITION BY TURBIDITY CURRENTS

Gravity flow deposits (turbidites, debris flows etc.) in the Barrandien area were studied, for example, by Suchý and Eckhardtová (1996) and Suchý (1997), mainly in the Přídolí (Požáry) Formation of the Silurian age. At the Silurian – Devonian boundary stratotype at Klonk near Suchomasty Davies and MacQueen (1977) interpreted – directly the boundary bed No. 20 as turbidity current deposit. Next research at Klonk was carried out by Hladil (1992), who presumed also localy reworking of distal turbidity currents by bottom traction currents. Diffrent opinion of sedimentary conditions (expecially of rhythmic alternation of calcareous shales with layers of limestones) proposed Chlupáč and Kukal (1977), who interpreted this alternation as a result of the changes of hemipelagic sedimentation and sediments influenced by non-suspensional traction currents. Chlupáč (2000 c) also explained alternation of layers of limestones with calcareous shales as a consequence of Milankovič precessional cycles.

Černá rokle near Kosoř

In the section at Černá rokle (Fig. 2), nearly the whole sequence of the Radotín Limestone of the Lochkov Formation can be regarded as turbidites, together with the lowermost (approximately 80 centimetres thick) part of the Dvorce-Prokop Limestone of the Pragian Stage. These still preserve the character of platy limestones with layers of calcareous shales. Starting from the thick bank of micritic nodular limestones No. 87 upward, different sedimentary regime in the basin is setting on – an overall calming, deepening and only a passive sedimentation of micritic mud with fluctuating influx of clay.

Turbidites at Černá rokle can taken, because of the predominance of laminated and micritic limestones, for typically distal, corresponding predominantly to T_D and T_E intervals of the Bouma sequence (Pl. 1, fig. 3). The succession of Bouma's intervals and the overall character of layers reflect evidences a sedimentation from diluted, marginal parts of turbidity currents, with only small erosive effect. This idea is supported also by a relation between layers of limestones and shale interbeds. The limestone beds usually sharply, but not erosively overlie the shale layers. Episodic stronger turbidity current localy deposited also coarser bioclastic layers – e. g. beds No. 56, 63, 64, the character of which coresponds to T_A or T_B intervals of Bouma sequence.

In the bed of laminated micritic limestone No. 65 (typical T_D interval), which directly overlies the coarser bioclastic layer No. 64, a convolution deformation of graded bedded laminae occurs (Pl. 2, fig. 2a, b). This is a typical deformation originated at the same time or only shortly after the turbidity current deposition as a result of overloading. This bed was later bioturbated by the ichnnofossil *Zoophycos* (Pl. 1, fig. 2).

Homolka near Velká Chuchle

Stratotype section at the Velká Chuchle (Fig. 3) represents, according to its development, a typical sequence of proximal parts of turbidite deposits. Especially in the Kosoř Limestone of the Lochkov Formation – near the boundary, the amalgamation of bioclastic pulses inside individual beds predominates. This also reflects the erosive capability of proximal turbidity currents. In these layers the T_A and T_B intervals of Bouma sequence dominate. This amalgamation was interrupted only in quiet periods by sedimentation of thin layers of calcareous shales. On the base of micritic laminated limestone layer No. 10 (T_D interval) even the ripple interval of Bouma sequence T_C is developed (Pl. 2, fig. 3). This interval is usually not evident in other sections.

As Suchý (1997) suggested, the question remains, whether thin layers of calcareous shales represent only a hemipelagic sediment, deposited independently on layers of calciturbidites, or if these layers were deposited as the T_E interval of Bouma sequence as the finest fraction of turbidity current. Observation on studied sections indicate that in the case that lamination exists at the transition between limestone and shale, it shows that a shale layer was affected by erosion and redeposition during next bioclastic pulse. These shale interbeds thus correspond to T_D or T_E interval of Bouma sequence and are typical for the Kosoř Limestone – Pl. 2, fig. 1. When the laminated interval is not developed (f. ex. Černá rokle), it points to rather calm deposition of a shale as a hemipelagic sediment, not infuenced by a sedimentation from distal calciturbidite current. It seems, that in proximal parts of turbidity current (Velká Chuchle) thin layers of shales become part of Bouma sequence, in contrast to distal parts (Černá rokle), where the passive hemipelagic sedimentation predominates.

The sequence of the Praha Formation at Velká Chuchle, close to the boundary with the Lochkovian, still keeps a character of turbidites, however, with highher content of micritic matrix. Turbidite regime here fades away upwards due to the increasing intensity of sedimentation of micritic nodular limestones (the same as in the section in Černá rokle near Kosoř).

Cikánka near Praha-Slivenec

In this section (Fig. 4), no indications of turbidite sedimentation are apparent close by the Lochkovian–Pragian boundary. Bioclastic accumulations of the Kotýs and Slivenec limestones (Pl. 1, fig. 1) served, in contrary, as the source of material for turbidity currents. The banks of bioclastic limestones (of total thickness of 15–20 m) sedimented originally as debris fans nearby the NW lying elevations (see the distribution of bioclastic facies in Fig. 1). These elevations were covered by extensive crinoid "forests". These bioclastic accumulations (Kotýs and Slivenec limestones) in the area of Cikánka, close the Lochkovian–Pragian boundary, are relied to the so-called Lochkovian–Pragian Event, and will be discussed bellow.

This shallow water development points to washing and sorting of crinoidal material within the reach of the waves, but also documents existence of a very large and dense

crinoid "forests" on these elevations. Their skeletal parts provided a large amount of debris to the elevation slopes. This material was distributed by turbidity currents both to proximal parts (Velká Chuchle), and farther to the distal parts (Černá rokle) of the basin. The transport was connected with a marked grain sorting. That is why at the Velká Chuchle section the coarser fractions are preserved – especially fraction of crinoidal debris, which corresponds to lower T_A, T_B intervals of Bouma sequence – and in the Černá rokle section rather finer, micrite-rich fraction (T_D, T_E intervals) of upper parts of Bouma sequence predominate.

Effects of the Lochkovian–Pragian boundary Event and their relations to the distribution of individual facies and turbidite regime

The Lochkovian–Pragian boundary in the Barrandian is important from the standpoint of the event stratigraphy. The so-called Lochkovian–Pragian boundary Event, which was studied in details namely by Chlupáč and Kukal (1986, 1988), manifests itself as relatively quick, synchronous event, which points to sudden drop of the sea level close to the Lochkovian–Pragian boundary. After this, a gradual redeepening during the whole Pragian stage took place. As Chlupáč and Kukal (1986, 1988) reported, this event is of global character and its effects can be observed also in other continents. It is evident also from biostratigraphical point of view, especially in associations of shallow and deep water organisms (Chlupáč *et al.* 1985).

As this event represents a very distinctive relative change of the sea level, it is possible – according to author's opinion – to call it according the generally accepted terms of sequence stratigraphy (that means system tract LST, TST, HST a. o.).

Cikánka near Praha-Slivenec

Taking into consideration lithological development in all three studied sections, this event manifests itself best in the shallow water environment – it means in the section at Cikánka. Here the exposed sequence of the Lochkov Formation starts with the typical Kosoř Limestone, where the amalgamation of the beds (Pl. 1, fig. 4) and erosive knobby surfaces of thin calcareous shales interbeds predominate.

These limestones probably correspond to deposits of the highstand system tract, which dominated in the basin before the regressive event itself. This concerns proximal turbidites, which had their source material on the NW – the elevational part of the Barrandian basin (approximately in the area of Svatý Jan pod Skalou, Loděnice, Chýnice etc. – see distribution of facies in the lower and middle Lochkovian in Chlupáč *et al.* 1972, 1998 etc.). In the uppermost Lochkovian (Fig. 1) a relative fall of the sea level (i. e. the regressive, Lochkovian–Pragian Event itself) caused that the bioclastic accumulations of the Kotýs Limestone from the NW elevation area prograded towards the SE and to the area of Prague (Zadní Kopanina, Cikánka). This mechanism took place during the lowstand system tract. These uppermost, coarse bioclastic parts of the Lochkov Formation were named by Svoboda and Prantl (1949) the Lower Koněprusy Limestone. The lowstand system tract (LST) continued also during the lower part of the Pragian, where is represented by the sedimentation of the Slivenec Limestone. The Slivenec Limestone in its upper part (above the section on Fig. 4) passes into the Řeporyje Limestone due to the increase of micritic matrix and this transition corresponds to the transgressive system tract – TST. Overlying analogous, but grey, Dvorce-Prokop Limestone, indicates the complete flooding of the basin and sedimentation in the highstand system tract (HST).

It should be pronounced, that the front part of these prograding fans (i.e., the Kotýs and Slivenec Limestones) remained the source area of turbidity currents. The turbidity currents had during the maximum reach of progradation their proximal parts demonstrable in the section at Velká Chuchle and their distal parts at Černá rokle near Kosoř. By further deepening during the Pragian (i.e., on fading regressive event itself) the crinoidal debris fans of the Slivenec Limestone "retreated back" (retrograded) to the elevation area in the NW. The front part of this retrograding accumulation of the Slivenec Limestone could serve, however, still as the source area of turbidity currents and these turbidites than correspond to sedimentation of platy Loděnice Limestone. These limestones are developed especially between the Slivenec and Řeporyje limestones and connected by gradual vertical and horizontal transitions (Chlupáč *et al.* 1992, 1998). Effects of the Lochkovian–Pragian Event on other two localities (Velká Chuchle, Černá rokle) are analogous.

Homolka near Velká Chuchle

At Velká Chuchle (Fig. 3), the lowstand system tract (LST) near the Lochkovian–Pragian boundary itself becomes evident especially by greater "proximity" of turbidites, i.e., by the increase of grain-size and amalgamation of limestone beds in the uppermost part of the Lochkov Formation. Gradual deepening, as the transgressive system tract (TST), starts in the Pragian Stage and becomes evident approximately from the limestone bed No. 26 upwards, where the increase of micritic matrix is observed. The maximum flooding of the basin (HST) is noticeable from around the bed No. 45 upward, where sedimentation of thick nodular banks of micritic limestones with abundant *Chondrites* burrows predominates.

Černá rokle near Kosoř

The section at Černá rokle (Fig. 2) reflects the effect of the Lochkovian–Pragian boundary Event far less, because of its basinal development. The lowstand system tract – LST (in other places expressed by increased bioclastic influx) is here hidden in monotonous sequence of distal calciturbidites. Even though they show a fluctuating bioclastic influx, they do not indicate clearly enough the sequence stratigraphy boundaries.

The development in the Černá rokle section can therefore represent the lowstand system tract (LST), but, on the other hand, also previous highstand system tract (HST). This also confirms the limited possibility of using sequence stratigraphy in basinal (and even turbidity) environments. On the contrary, the gradual transgression (TST) and highstand system tract (HST) can be very well seen here. The deepening becomes lithologically well manifested from the bed No. 80 (which is also the base of the Praha Formation) and in overlying beds, namely by fining and lightening of the Dvorce-Prokop Limestone layers. As these

beds are interpreted as distal turbidites, this fining points very well to gradual transgression and shifting of the source area of these turbidites back to the NW. Distal turbidites of the Lochkov Formation (the Radotín Limestone), therefore, become from the base of the Praha Formation (bed No. 80) even "more distal". Above this finest fraction of turbidites (typical mudstones of T_E intervals of Bouma sequence), the highstand system tract (HST) dominates. Its effects appear as in other sections in sedimentation of nodular, biomicritic limestones with fluctuating content of clay and with abundant ichnofossil *Chondrites*.

CONCLUSION

The sedimentological research carried out on three localities of the Lochkovian–Pragian boundary interval in the Lower Devonian of the Barrandian area (including the stratotype) led to the following conclusions:

Taking into consideration the characteristics of studied formations and especially their sedimentary structures (i.e., the lamination, fining upward, convolution deformation, current ripples, etc.), alternation of limestones and layers of calcareous shales, the fauna differences, the gradient of the basin, it is possible to explain some studied parts of sections as deposits of turbidity currents.

At the Černá rokle near Kosoř, turbidites form the facies of the Radotín Limestone of the Lochkov Formation together with the lowermost part (approximately 80 cm) of the Dvorce-Prokop Limestone of the Praha Formation. These turbidites, according to predominance of Bouma's interval T_D and T_E, can be classified as distal submarine fan deposits.

At the section Homolka near Velká Chuchle (the international stratotype of the lower Pragian boundary) the lithologic development of the Lochkov and the lower part of the Praha formations represent the proximal part of the calciturbidites. The amalgamation of the beds is the predominat feature and especially the Bouma's intervals T_A and T_B (rarely even ripple's interval T_C) are present.

Shallow water development of the uppermost part of the Lochkov Formation and the lower part of the Praha Formation at the Cikánka near Praha-Slivenec is considered to be the provenance of bioclastic accumulations of the turbidites themselves. These turbidites were supplied by crinoidal detritus from the adjacent elevations in the NW parts of the basin. Thick banks of the Kotýs and Slivenec limestones represent the bioclastic fans derived from the elevations.

As the lithologic development of the Kosoř and Radotín Limestones of the Lochkov Formation in the Barrandian area is relatively constant, the idea about their origin by turbidity currents can be applied to these facies even at other localities. The same situation is in the lowermost part of the Praha Formation (e. g. in the Dvorce-Prokop Limestone), in case that they keep a character of platy limestones with thin layers of calcareous shales. The shale interbeds than represent hemipelagic sediment, which was – mostly passively – deposited between the calciturbiditic layers (in their distal parts – Černá rokle near Kosoř), or could have been resedimented by these currents as the Bouma's T_D and T_E intervals (in their proximal parts – Homolka near Velká Chuchle).

Bioturbation occurs mostly in such beds, which were not markedly influenced by turbidity currents (upper part of the Dvorce-Prokop Limestone of the Pragian Stage). Except of frequent ichnofossil *Chondrites*, the ichnofossil *Zoophycos* has been newly found in the studied sections, in the Radotín Limestone of the Lochkov Formation at Černá rokle near Kosoř.

The Lochkovian–Pragian boundary Event (Chlupáč and Kukal 1986, 1988) has been in this paper interpreted in terms of sequence stratigraphy, as it entirely corresponds to relative sea level changes, described by sequence stratigraphical models. Studied sections show its good usage in cases of shallow water development, but problematic definition of the sequence stratigraphy boundaries in the deep water basinal development.

This regressive event had in the Barrandian area the fundamental influence on distribution of facies near the Lochkovian–Pragian boundary, in proximity of the Lochkovian–Pragian boundary interval. By relative fall of the sea level (LST) the bioclastic accumulation of the Kotýs and Slivenec limestones prograded from elevation areas in NW towards SE and towards the area of Prague. Front part of these bioclastic accumulation served even during the progradation as the source area of turbidity current, whose proximal development is observable in the section at Homolka and in the distal development at Černá rokle near Kosoř.

During the successive gradual deepening (TST) in the Pragian, this accumulation (the Slivenec Limestone) again "retreats back" (retrogrades) to the elevational areas in the NW. This transgressive regime is relied in the basin with sedimentation of the Řeporyje Limestone (for example Cikánka and elsewhere). Later the platy Loděnice Limestone plays the role of the "front part" turbidites. The Loděnice Limestone is usually developed between the Slivenec and Řeporyje Limestones – farther to the NW being documented in many sections of the NW flank of the Barrandien (Chlupáč 1957, 1992, 1998).

In all the studied sections, the maximum flooding (HST) during the upper part of the Praha Formation is evident. This causes general deepening and sedimentation of nodular, micritic Dvorce-Prokop Limestone. These limestones terminate the Pragian sequence at all localities studied.

This development of the basin in the Lower Devonian was interrupted by the basal Zlíchovian Event (Chlupáč, Kukal 1986, 1988), which caused the changes in overall regime of the basin, the reorganization of depocentres of bioclastic and lithoclastic materials and immigration of new kinds of faunas as well (see, e. g. Chlupáč 1957, 1993, Havlíček 1994, Chlupáč and Kolář 2001 etc.).

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1



2 cm

2



3



Plate 1

1 – Outcrop of thick banks of the Slivenec Limestone. Example of shallow water development of the Lochkovian – Pragian boundary interval. The banks represent biodetrical debris fan deposits, formed especially by crinoidal fragments, which were the main source for turbidity currents. Cikánka near Praha-Slivenec, Praha Formation (Pragian).

2 – The ichnofossil *Zoophycos* forms several millimetres thick downwards denticulated structures in the micritic limestone bed No. 65. Černá rokle near Kosoř, Lochkov Formation (uppermost Lochkovian). Photo P. Čáp.

3 – The Lochkov Formation (Radotín Limestone facies) in the Černá rokle near Kosoř. An example of distal turbidity depositions. Alternation of platy limestones (calciturbidites) with calcareous shale interbeds (hemipelagic sedimentation) is characteristic.

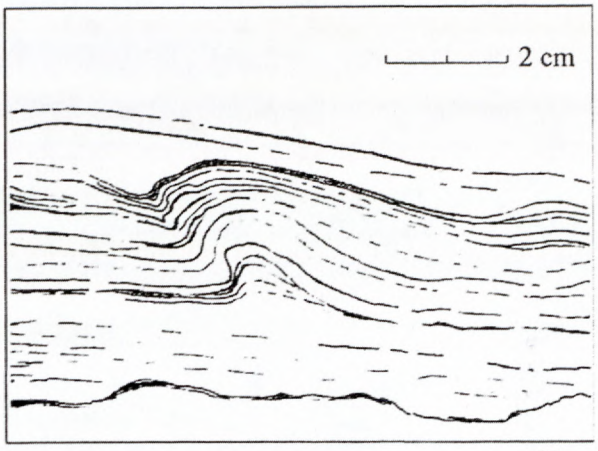
4 – Amalgamation of layers of the proximal parts of calciturbidites. Darker stripes represent frequently laminated, erosively deformed layers of calcareous shales. Kosoř Limestone of the Lochkov Formation (uppermost Lochkovian), Cikánka near Praha-Slivenec.



1



2a



2b



3

Plate 2

1 – Transition from coarse bioclastic layers of limestones to laminated layers of calcareous shales. Homolka near Velká Chuchle, Lochkov Formation (uppermost Lochkovian). Bouma's intervals T_A, T_B and upper lamination T_D. (Photo P. Čáp).

2a, 2b – Convolution deformation of laminae formed by fine organic detritus within the micritic limestone layers No. 65. A typical deformation originated at the same time or only shortly after the turbidity current deposition as a result of load of the deposited material. Černá rokle near Kosoř, Lochkov Formation (uppermost Lochkovian). (Photo P. Čáp).

3 – Current ripples at the base of the bed No. 10. Ripple interval T_C of the Bouma sequence. Homolka near Velká Chuchle, Lochkov Formation (uppermost Lochkovian). (Photo P. Čáp).

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CRETACEOUS BRYOZOA IN THE WORK OF OTOMAR P. NOVÁK

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Abstract: Otomar P. Novák (1851–1892) belongs among the early pioneers who had made considerable contributions to the bryozoology of Bohemia, especially in understanding the morphology of Cretaceous Bryozoa. Details about his study of bryozoan faunas are summarized. The comparison between his scientific surveys and recent methods of study are given. Information and comments concerning importance of his work and citation index of his paper are included.

INTRODUCTION

Otomar Novák was one of the ancestors of Joachim Barrande. His paper "Beitrag zur Kenntniss der Bryozoen der böhmischen Kreideformation" (Novák 1877) is the most important contribution to the knowledge of Cretaceous Bryozoa from Bohemia also for nowadays, and up to now it is the largest monograph on this topic at all.

CRETACEOUS BRYOZOA IN NOVÁK 1877

Czech Cretaceous sediments can be divided into seven stratigraphic units (according to many recent authors, basically Cicha 1984). Novák used similar stratigraphy; he divided the Cretaceous sediments into 8 facies (layers). A comparison of his framework and the recently used one is given in Table 1. As shown in this table, the only difference is that Novák (1877) used separately the "Perucer" layers and the "Korycaner" layers, regarded recently as members of the Peruc-Korycany Formation.

Novák collected his material around the village of Bílina, but he also studied the material collected by A. Frič and J. Krejčí. Beside that, similarly as his teacher J. Barrande, he used material collected by amateur collectors, especially by J. Pražák from Choroušany. Altogether, he studied materials comming from 17 localities of Cenomanian to Turonian age (Tab. 2.). I have found all the recently used names for these localities, except the locality Bezděkau. According to Dr. Nekvasilová (pers. com., 2002), the locality Bezděkau is recently probably called Bezděčín near Hodkovice above Mohelka.

Novák described 45 species of Bryozoa, of which 33 he considered as new. All the species are described in detail and illustrated by very high quality drawings. The drawings are, in many respects, more informative than electron microscope photographs as shown in the Plate 1. As an example, Cretaceous specimens found in Scharrargraben in Austria are used, where the preservation is very similar to the Czech material. The Novák's drawings are very well done; he discovered many taxonomically important details of the external structures of zooecia. While scanning pictures depend very much on the state of preservation (as seen on Figs. 9–10), the drawings can omit the imperfections and therefore are more informative. Also, the details of development of frontal walls (for example like in Cyclostomes on Fig. 3–4) are better visible on the Novák's drawings if compared with modern scanning photographs. On the other hand, the drawing already represents an interpretation of the knowledge of the bryozoan morphology. Therefore, the details of muscle scars visible on scanning photographs are not present on Novák's drawings (e.g. Figs. 5–6).

The bryozoan classification used by Novák (1877) is very similar to the modern classification. Novák considered both the gross morphology and features occurring on the reproductive organs (ovicells and gonozooecia) as the most important. Such a classification fits well with the modern approach and thus major part of the Novák's species is still valid. Novák discussed also problems of the genera established by d'Orbigny (1852) representing mostly probably morphotypes only. This is an actual problem, which has not been solved recently. In his original paper d'Orbigny (1852) established number of bryozoan genera based on growth forms. In his opinion, the growth form represents the most important generic feature. Therefore he named the erect morphotypes as *Semieschara*, the encrusting colonies as *Multiporina*, etc. He did not evaluate any other feature as important for the classification of genera. Recently, we know that the most important features are presented on the autozooecia and heterozooecia and also that the same species could grow in different growth form (for example, many species of *Schizoporella* can be encrusting if living in shallow water, but can be erect and multilamellar, when living in the depth of more than 100 m), similarly as in Recent taxa. The paper of d'Orbigny was, however, published very early and therefore many of his genera should have the priority instead of the later names, established according to autozooecial and heterozooecial features.

Recently we face the main problem, whether we should use d'Orbigny's names of genera and follow the priority rule (being not sure about the correct generic features), or to use

Table 1 Stratigraphy of the Czech Cretaceous sediments used by Novák (1877) and by recent authors (for example Cicha 1987). The numbers of localities and species in each formation are only those described by Novák (1877). Environment is adapted from Cicha (1987).

stratigraphy		number of		age		environment
by Novák (1877)	recently used (Cicha, 1984)	localities	species	by Novák (1877)	by Cicha (1984)	
Perucer	Perucko-	0	0	Cenomanian	Albian?-Cenomanian	alluvial to deltaic
Korycaner	Korycanské	8	36	Cenomanian	Cenomanian	marine-shallow
Wessenberger	Bělohorské	1	1	Turonian	lower Turonian	marine – deep
Malnicer	Jizerské (mělnická facie)	1	1	Turonian	middle Turonian	marine – shallow
Iser	Jizerské	7	8	Senonian	middle Turonian	marine – shallow
Teplizer	Teplické	3	8	Senonian	Turonian – Coniacian	marine – deep
Priensener	Březenské	0	0	Senonian	Coniacian	marine – glyshoidal
Chlomer	Merboltické	0	0	Senonian	Santonian	marine – regressive

Table 2 List of the localities (with recent names) and the numbers of described species by Novák (1877).

name of locality		number of bryozoan species			age
By Novák, 1877	recently used	total	cheilostomatous	cyclostomatous	
Kamajk	Kamajka by Chotusice	25	10	15	lw. Turonian
Velim	Velim	5	3	2	lw. Turonian
Zbislav	Zbyslav by Čáslav	13	3	10	lw. Turonian
Hundorf	Hudcov u Teplic	5	4	1	mid. Turonian
Schillinge	Libčické údolí	5	3	2	lw. Turonian
Lehmbruche b. Laun	Bílé Horky u Loun	1	1	0	up. Turonian
Kolin	Kolín – různé lokality	8	0	8	lw. Turonian
Jung-Bunzlau	Mladá Boleslav	1	1	0	Turonian
Gross Ujezd	Velký Újezd	7	1	6	mid. Turonian
Chorouschek	Chorušky	3	1	2	mid. Turonian
Brandeis a. d. Adler	Brandýs nad Labem	2	1	1	mid. Turonian
Bezděkau	Bezděčín by Hodkovice	2	0	2	
Weisskirchlitz	Novosedlice u Teplic	1	0	1	Turonian
Hrádek	Hrádek	1	0	1	Cenomanian
Korycan	Korycany	3	0	3	Cenomanian
Vtelno	Vtelno	2	0	2	mid. Turonian
Lindenau	Lindenava	2	0	2	mid. Turonian
Rovensko	Rovensko pod Troskami	1	0	1	mid. Turonian
Total	**17**	**45**	**16 (10 new)**	**29 (23 new)**	

the more modern names with exactly defined features and violate the priority rule. Many authors nowadays use the new generic names and omit the poorly defined genera established by d'Orbigny. However, Novák already discussed this problem and noted, that the d'Orbigny genera are very poorly defined and therefore not useful; nevertheless he used the d'Orbigny genera names respecting the priority rule.

In his paper Novák compared the Bohemian bryozoan fauna with that of the Boreal area. The comparison with the boreal fauna is discussed also recently. According to the Dr. O. Nekvasilová (pers. com. 2002), the Cretaceous fauna of the Czech Republic originated more probably from the northern Boreal area, rather than from southern or eastern Tethys Sea. Therefore, we can consider the Novák's results as very modern and actual in this respect.

IMPORTANCE OF NOVÁK'S WORK FOR THE RECENT RESEARCH

Many species described by Novák (1877) have been still valid and frequently used. Nevertheless, Cretaceous Bryozoa from Bohemian localities have been studied only very sporadically.

The first person describing Cretaceous Bryozoa from Bohemia was Reuss (1846) who determined altogether 12 species from localities of the recent Czech Republic. Novák (1877) revised these species and made new drawings. Because illustrations by Reuss (1846) are very poor and the material was lost (probably damaged during the Second world war), the Novák's drawings represent the best illustrations of these species. After Novák, also Počta (1892) published a study devoted to the locality Kaňk (near Kutná Hora). Beside these three monographs, only a few short remarks were published about Bohemian Cretaceous

bryozoan fauna (Prantl 1938, 1940; Zázvorka 1951, 1952). Hradecká (1984) recently published new finds of the cyclostomatous Bryozoa from the locality Zbyslav. Žít and Nekvasilová spent many days in field collecting Bryozoa in southern part of the Czech Cretaceous Basin. These materials have not been studied. Therefore, a thorough revision of Novák's work including detailed taxonomy of the new collections are still needed.

The importance of Novák's paper could be measured, similarly as in recent papers, by the citation index. Because there exists no large study of Bryozoa from Bohemia, the citation index of the Novák's paper is not as high as expected. Except for studies dealing with Bohemian fauna, the Cretaceous Bryozoa from Europe are recently studied mainly in northern Germany and southern England. Voigt has described the most comparable material from Germany. He has cited Novák in 13 generally monographic papers (from 1928 to 1998), but also in several shorter contributions dealing with special taxonomic problems. Moreover, there are more than two other papers (e.g., Larwood 1962 and Pitt, Taylor 1990) describing fauna from southern England, in which the Novák's paper and his determinations were applied. All of his species are still in use, however, mostly listed under different genera names.

Since 1877, when Novák's paper was published, it has been referred in 21 scientific papers dealing with Bryozoa.

SUMMARY

As shown above, the Novák's work represents the first and still the largest monograph on Cretaceous Bryozoa from Bohemia. Although his determinations and descriptions need a thorough revision, his importance for the present study of Cretaceous Bryozoa from Bohemia cannot be overlooked.

Acknowledgement. This paper was written thanks to a kind help of Dr. R. Horný who improved the English and provided many helpful comments concerning the Novák's historical paper. My thanks go also to Dr. O. Nekvasilová, who helped me with the introduction to Bohemian Cretaceous and also understanding Novák's importance for the Czech palaeontology. Also the staff of the Department of Palaeontology from the National Museum (Prague) helped in my work. I would like to express my sincerely thanks to all of them.

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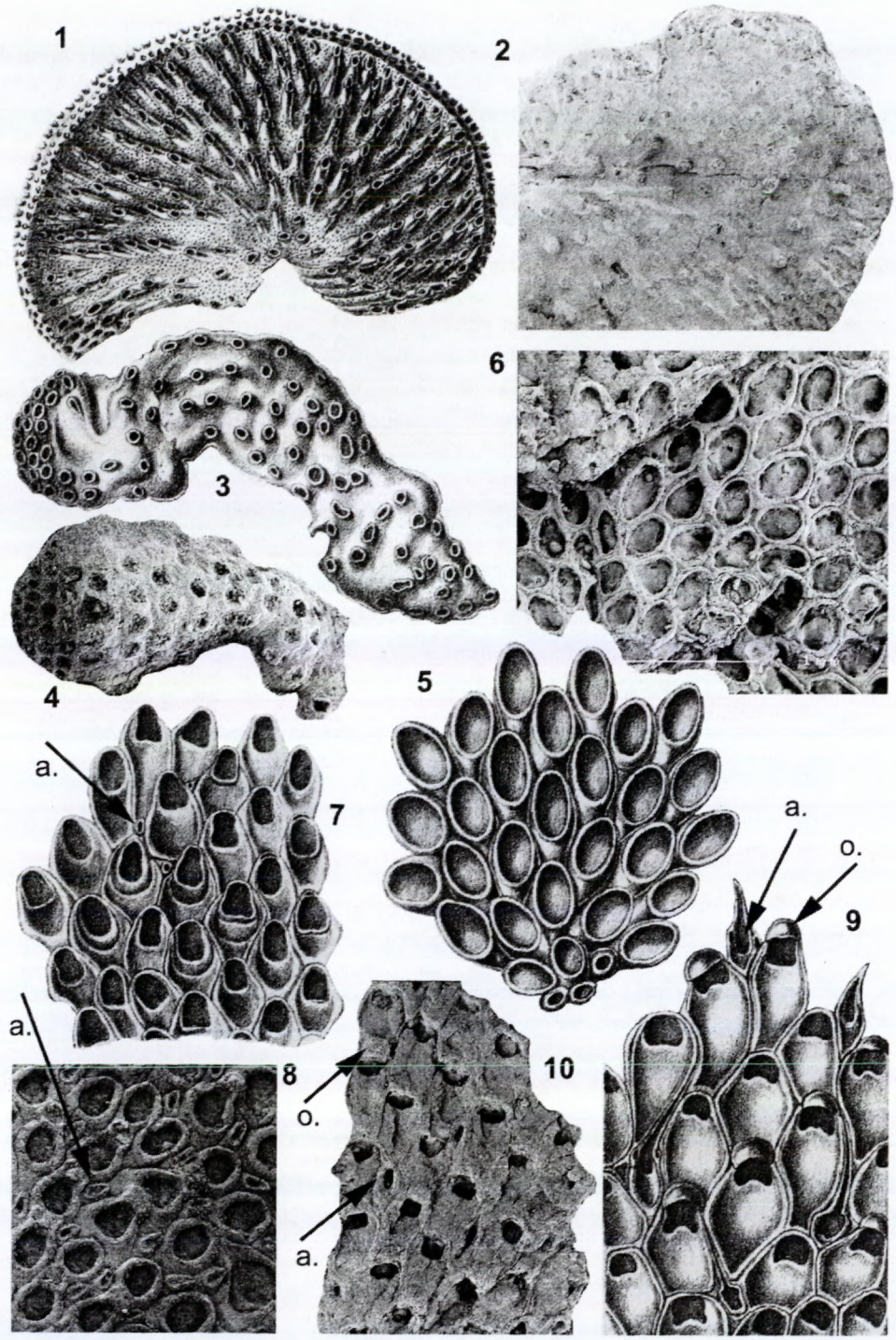
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1 – *Berenicea radians* Novák, 1877. Reprint from Novák, 1877: Pl. 4, fig. 16. Note small pores visible on the surface of the colony and zooecial tubes without pores. locality Kamajka by Chotusice. 25x enlarged.

2 – "Berenicea" Very similar species as Novák's. Because no gonozooecia are developed, the precise determination is uncertain. Scharrargraben (Austria). 25x enlarged.

3 – *Proboscina bohemica* Novák, 1877. Reprint from Novák, 1877: Pl. 5, fig. 25. Note proximal end of the colony and circular shape of the apertures. Velký Újezd. 16x enlarged.

4 – *Proboscina* sp. No ovicels is known, so species determination remains uncertain. Scharrargraben (Austria). 15x enlarged.

5 – *Membranipora elliptica* von Hagenov. Reprint from Novák, 1877: Pl. 2, fig. 15. Note size and shape of apertures. Because of lacking of avicularia and ovicels, the species attribution of this specimen cannot be proofed. Hudcov by Teplice. 24x enlarged.

6 – *Alderina dilatata* Reuss, 1845. Very similar specimen to *Membranipora elliptica* von Hagenov by Novák, with visible muscle scars. Scharrargraben (Austria). 25x enlarged.

7 – *Membranipora curta* Novák, 1877. Reprint from Novák, 1877: Pl. 1, fig. 6. Note small circular avicularia (a.) and size and shape of apertures. Kamajka by Chotusice. 20x enlarged.

8 – *Copidozoom curta* (Novák, 1877). Same species as Novák's only the avicularia (a.) are slightly enlarged in comparison with Novák's specimens. Scharrargraben (Austria). 18x enlarged.

9 - *Membranipora irregularis* von Hagenov. Reprint from Novák, 1877: Pl. 1, fig. 14. Note number and shape of avicularia (a.) and ovicells (o.). According to Voigt (1989) this specimens belong to *Onychocella reussi* Prant, 1938. Kamajka by Chotusice. 10x enlarged.

10 – *Onychocella reussi* Prant, 1938. Fragment of a colony showing same ovicels (o.) and avicularia (a.) as Novák's specimens. Scharrargraben (Austria). 5x enlarged.

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LATE SARMATIAN SEDIMENTS (SKALICA FORMATION) OF THE VIENNA BASIN NORTHEASTERN MARGIN

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Abstract: Late Sarmatian sediments of the Slovak part of the Vienna Basin are represented by the Skalica Formation (Elečko and Vass 2001). The sediments of the mentioned formation are cropping out at the territory extending between the towns Holič and Skalica. The occurrences of Late Sarmatian sediments also continue farther to the neighbourhood of the town Strážnice in the Czech Republic (Dornič and Kheil 1963) where they form the upper part of the Bílovice Formation (Čtyroký 2000).

The Skalica Formation is predominately formed by fine to medium-grained sands and sandstones of grey to greyi-shellow colour with horizontal ripple-mark to diagonal bedding. The formation originated in an environment of delta prograding to the brakish sea (Elečko and Vass 2001). The marginal member is the Karlova Ves Member, formed at the base by breccias and conglomerates, with pass into overlying calcareous sands/sandstones and organodetrital, bryozoan-serpulid, oolitic limestones and limestones with nubecularians (Nagy *et al.* 1993).

The partial stratotype profile of the Skalica Formation is the outcrop near the bus station in Skalica (Elečko and Vass 2001, fig. l.c.). In sediments exposed at this profile a rich fauna of molluscs (gastropods, bivalves), foraminifers and ostracodes has been found (Fordinál and Zlinská 1998).

From gastropods in largest amount were found: *Pirenella picta mitralis* (Eichwald), *Hydrobia elongata* (Eichwald), *Acteocina lajonkaireana* (Basterot) and *Clithom pictus* (Férussac). From bivalves dominant was the species *Ervilia dissita podolica* (Eichwald). In less amount the species were found: *Irus dissitus* (Eichwald), *Cerastoderma vindobonense* (Laskarev) and *Musculus sarmaticus* (Gatujev). From foraminifers in largest amounts were represented the species *Ammonia beccarii* (L.), *Porosononion granosum* (Orb.). In less amount were found *Elphidium aculeatum* (Orb.), *E. fichtelianum* (Orb.), *E. macellum* (F.-M.), *E. rugosum* (Orb.) and *E. glabrum* Bystrická. In the association of ostracodes in largest amount were found the species *Cyamocytheridea leptostigma leptostigma* (Reuss), *Hemicytheria omphalodes omphalodes* (Reuss), *Callistocythere egregia* (Méhes) *Neocytherideis* sp. and *Aurila notata* (Reuss).

Sediments of the Skalica Formation, situated west of the town Holíč, at the slope of elev. p. Hrebeň, are formed by light-grey disintegrating sandstones, which form layers 30 cm thick (Baňacký *et al.* 1996). In them were established gastropods *Pirenella picta mitralis* (Eichwald), *P. picta nympha* (Eichwald), *Gibbula hoernesi* Jekelius and *Bittium fraterculus* (Mayer), bivalves *Irus dissitus* (Eichwald), *I. gregarius* (Goldfuss) and *Cerstoderma latisulcum* Muenster. From ostracodes in largest amount *Cyamocytheridea leptostigma leptostigma* (Reuss), *Hemicytheria omphalodes omphalodes* (Reuss), *Phlyctenophora farkasi* (Zalányi) and *Aurila notata* (Reuss) (Fordinál 1993).

The presence of rich assemblages ot individual groups of fossil organisms has made possible following stratigraphical ranging ot the localities mentioned above. On the basis of foraminifers the sediments belong to the Porosononion granosum Zone (according to Grill 1941), on the basis of ostracodes (according to Zelenka 1990) to the zone of abundant occurrence of Aurila notata – Cyamocytheridea leptostigma leptostigma and the locality Skalica also to the Hemicytheria hungarica – Leptocythere cejcensis Subzone. On the basis of molluscs the locality Holíč belongs to the Mactra Member (according to Papp 1954).

In sediments of the Skalica Formation at the locality Skalica an occurrence of marine forms of gastropods (*Acteon vindobonensis* Handmann), foraminifers (*Bulimina, Bolivina, Globigerina, Globigerinoides*) and ostracodes (*Neocytherideis*, *Cnestocythere*) has been established. Their occurrence was also reccorded in other parts of the Central and Eastern Paratethys (Bobrinskaja and Buryndina 1981, Brestenská 1972, Buryndina 1974, Cernajsek 1974, Pokorný 1954, Zelenka 1989). The presence of marine forms of organisms points to short-dated communication of the Central and Eastern Paratethys with the Tethyan realm throughout the Late Sarmatian s. str. (in the Eastern Paratethys Middle Sarmatian s. l.).

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