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EARLY CRETACEOUS AMMONITE ASSOCIATIONS IN THE WESTERN CARPATHIANS (THE MORAVIAN-SILESIAN AREA AND WESTERN SLOVAKIA)

SPODNOKŘÍDOVÉ AMONITOVÉ ASOCIACE V ZÁPADNÍCH KARPATECH (MORAVSKOSLEZSKÁ OBLAST A ZÁPADNÍ SLOVENSKO)

ZDENĚK VAŠÍČEK

Abstract

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Early Cretaceous ammonite associations in the Western Carpathians (the Moravian-Silesian area and Western Slovakia)

From the geological point of view, the north-eastern part of the Czech Republic and the greater part of the neighbouring Slovakia are built by the Western Carpathian Mountains system. They mainly consist of two basic geological units – i.e. the Outer Western Carpathians and the Central Western Carpathians. The Silesian Unit of the Godula development in the Outer Carpathians, and the Pieniny Klippen Belt together with the Central Carpathians in Slovakia, which is generally spread from the northwest to the southeast, are the most important units in this system, discussed in the first part of the paper submitted. Occurrence of Valanginian to Aptian stratigraphic indexes comprised in ammonite associations in the units described above, are reviewed. On the other hand, the representatives of long living forms of suborders Phylloceratina and Lytoceratina are of minor stratigraphic value. The follow-up discussion is based on information presented in Table, showing only the stratigraphic positions of zonal ammonite indexes, in all three studied units of the Western Carpathians. The findings are parallelized and compared with the current Early Cretaceous ammonite standard zonation of Reboulet *et al.* (2018). Warm-water Mediterranean ammonite association predominates in all three units studied. Some genera, originated from the Mediterranean bioprovince, extended from west to east across Danish-Polish depression into Boreal zone. The genus *Platylenticeras* passed from the Boreal zone towards the Silesian Unit for a short time in the early Valanginian; the genera *Dichotomites* and *Neocomites* cf. *peregrinus* passed towards the Central Carpathians in the late Valanginian. In some periods (Barremian and early Aptian), the ammonite association of the Silesian Unit differs somewhat from the association of the Pieniny Klippen Zone and the Central Carpathians, probably due to the palaeogeographic position of the Silesian Unit with a different facial development. The conclusion is focused on palaeogeographic findings which have influenced the composition of ammonite associations in sedimentary areas located southeast-wards from the former North-European platform. The main aim of this paper is to inform about the occurrence of Lower Cretaceous ammonites of current zonal importance in the Mediterranean faunal province of the Western Carpathian units.

Key words: Outer and Central Western Carpathians, Valanginian up to Aptian, ammonite indexes.

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1. INTRODUCTION

The contribution presented addresses the development of Early Cretaceous ammonite associations in neighbouring tectonic units in the Western Carpathians, and their compa-

rison with the contemporary standard international ammonite zonation in Reboulet *et al.* (2018). In particular, the localities examined were the Silesian Unit in the Outer (Flysch) Western Carpathians of the Moravian-Silesian area, some localities of the Pieniny Klippen Belt in Western Slovakia, and significant localities in the Krížna and Manín Nappe in the Central Western Carpathians (fig. 1). The data concerning local ammonite spectrum in these units were revised and updated, following the catalogues of Lower Cretaceous ammonites (Klein *et al.*, starting from 2005), and following other modern taxonomy knowledge published during this millennium.

The Lower Cretaceous ammonite-bearing sediments in the Outer Western Carpathians in the Silesian Unit of the Godula development differ distinctly in their lithology from similarly aged sediments in the Pieniny Klippen Belt and in the Central Carpathians. The Moravian-Silesian Early Cretaceous sequence is characterised by its flysch development dominated by a pelite component. At some locations, namely in its late Hauterivian part, in the sections with a prevalence of calcareous to non-calcareous pelites, layers dominated by graded bedding sandstones occur. The grey or dark grey claystone and marlstone colouring means that this unit is sometimes referred to as the "black" Cretaceous (fig. 2). Pelitic sediments are accompanied by isolated horizons of lenticular clay ironstones (claystone siderites) mined in the fore-last century as a source of iron ore. The palaeontological results of Vašíček (1972, 1973 a, b, 1975, 1981, 2008, 2009), Vašíček and Klajmon (1998), Vašíček and Skupien (2002), Eliáš *et al.* (2003) and Vašíček *et al.* (2004) follow on from the historic lithology, biostratigraphy and ammonite findings of Hohenegger (1861) and papers to taxonomy of Uhlig (1883, 1902).

Localities selected in the Pieniny Klippen Belt are represented by the Podbranč Quarry near Myjava, by the Na Dlhej Quarry near Horné Srnie, by Mt Rochovica near Brodno, by Revišné Quarry and Podbiel Quarry in the Orava Basin (topographical situation in Vašíček 1991, inset 4). These localities are characteristic for their extremely complicated geological nappe structure, yielding sections with incontinuous rock sequence with incomplete record of ammonite occurrence. The lower part of the rock sequence (Valanginian to late Barremian) is developed in marly-calcareous facies. During Aptian, pale grey carbonates were usually replaced by dark grey diagenetically less compacted marlstones of the Koňhora Formation (Andrusov and Samuel 1973) without ammonites. Localities listed above were completed among others by Vašíček *et al.* (1992), Vašíček (2002), Skupien *et al.* (2003).

The most complete ammonite-bearing Early Cretaceous sequence (the Valanginian to the late Barremian) is located in the Central Western Carpathians, the leading localities being primarily represented by the Butkov Quarry near Ladce in the Váh Valley and the Polomec Quarry near Lietavská Lúčka. Pelagic marly-carbonate sediments are of light colour. Some parts of the sequence contain cherts and turbidite layers. The sediments in the Butkov Quarry were, and still are, mined as a raw material for the production of cement. Lithostratigraphic subdivision in the Early Cretaceous of the Manín Unit at Butkov was completed by Borza *et al.* (1987). The taxonomy and biostratigraphy of Early Cretaceous ammonites were studied by Vašíček and Michalík (1986, 1988), Vašíček (2005, 2006, 2010), Vašíček and Malek (2017); recently Vašíček (2020 a, b), Vašíček and Klein (2021) and Vašíček 2022 (in prep.).

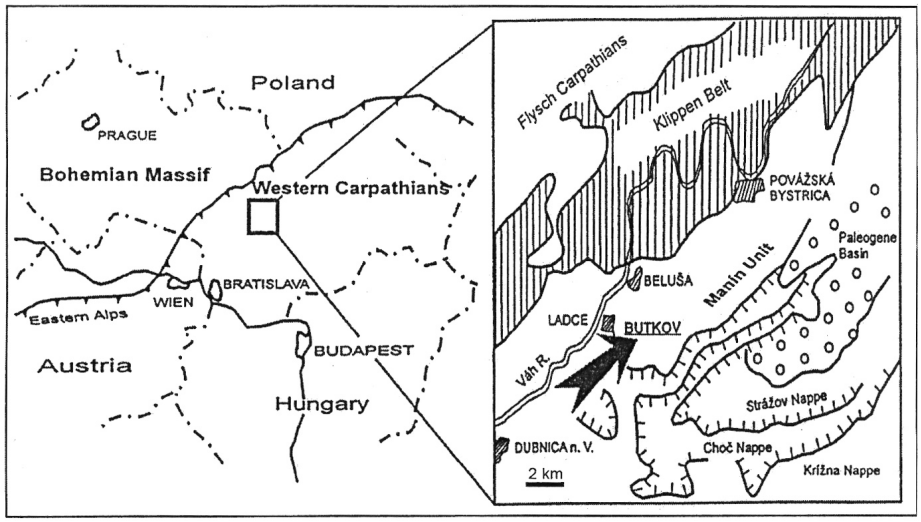

Fig. 1. Scheme of the main geological units in the Czech and Slovak Western Carpathians. Circles illustrate conglomerates and sandstones in the post-tectonic basin.

Obr. 1. Schéma hlavních geologických jednotek českých a slovenských Západních Karpat. Kroužky ilustrují slepence a pískovce v posttektonické pánvi.

Fig. 2. Typical development of Lower Cretaceous deposits in the Silesian Unit. Abandoned quarry in the village of Kunčice p. O.

Obr. 2. Typický vývoj spodnokřídových uloženin ve slezské jednotce. Opuštěný lom v obci Kunčice pod Ondřejníkem.

2. MATERIAL AND METHODS

The present paper is based mainly on field collections and the author's knowledge gathered during 60 years of research, as well as processing of the collected ammonites from the Lower Cretaceous in the Czech and Slovak Western Carpathians. The collections were processed in all three units mentioned in Introduction.

The earliest collecting were realized in the Silesian Unit of the Godula Development, mainly in the years 1963 to 1971. Besides the taxonomic evaluation of own material (published in the years 1972 to 2008), the author also revised the original material from collections of Hohenegger (1861), which was later processed by Uhlig (1883, 1902). This material is today deposited in Vienna and Munich (revised in Vašíček 1973, 1975, Vašíček and Wiedmann, 1994). Other findings were elaborated later (e.g. Vašíček and Klajmon 1998, Vašíček 2008, Vašíček and Skupien 2002, Vašíček *et al.* 2004).

From year 1982, in collaboration with Assoc. Prof. J. Michalík, the author regularly carried out macrofaunal collections at sites in the Central Western Carpathians as part of the Slovak research projects. The most important sites were the quarry on Polomec Hill near Lietavská Lúčka and the Butkov Quarry near village Ladce (in Považí). The main results were published in Vašíček *et al.* (1983), Vašíček and Michalík (1986, 1988), Vašíček (2005, 2006, 2010), Michalík, Vašíček *et al.* (2013), Vašíček and Malek (2017), Vašíček (2020 a, b, in prep.), Vašíček and Klein (2021).

Besides the Central Carpathians, macrofaunal collections were occasionally carried out also in the Pieniny Klippen Belt. The results were published, e.g. in Vašíček *et al.* (1992), Vašíček (2002) and Skupien *et al.* (2003).

Identified ammonites from author's own findings in the Silesian Unit are deposited in the collections of the Czech Geological Survey in Prague, later in the collections of the Museum of Ostrava. Findings from the Slovak Carpathians are or will be (in prep. and new) deposited in the collections of the Slovak National Museum in Bratislava.

3. SILESIAN UNIT

The ammonites from the "black" Early Cretaceous sequence in the Silesian Unit of Godula basinal development can be divided into two basic groups: the lower Valanginian to the upper Valanginian, and the lower Barremian to the upper Aptian. The Valanginian ammonite association is closely related to Hohenegger's historical collections and to Uhlig's monography. Ammonites occur in clay ironstone concretions in sediments which used to be classified as the Upper Těšín Beds. Further findings of ammonites came to an end once clay ironstone mining ceased. In most findings, Hohenegger only stated the settlement nearest to the location of the finding and did not provide an accurate stratigraphic position. These species were mostly identified as new by V. Uhlig (1902), although at times he adopted Hohenegger's provisional generic determination. In many cases, their undetermined stratigraphic position was specified additionally in later publications, based on the occurrence in other stratified localities in the Europe. In some specimens, unclarities up to the level of stratigraphic degree persist to date. Distribution and proven or supposed stratigraphic position of Uhlig's genera has been correlated with current Reboulet *et al.* (2018) ammonite zones, as shown in the tab. 1.

Most species depicted and described by Uhlig (1902) from a historical collection originated since early Valanginian. Species of zonal character, such as *"Thurmanniceras" pertransiens* (Sayn), *Neocomites neocomiensiformis* (Hohenegger in Uhlig), *Vergoliceras salinarium* (Uhlig), *Busnardoites campylotoxus* (Uhlig), and other species such as *Kilianella pexiptycha* (Uhlig), *Kilianella clavicostata* Nikolov, *Bochianites neocomiensis* (d'Orbigny) and also lesser known Uhlig's species as *Fuhriella michaelis*, *F. hoheneggeri*, *F. hystricoides*

Tab. 1. The distribution of the guide species of Aptian up to Valanginian at the basic units of the Western Carpathians in Czech and Slovak territory.

Tab. 1. Distribuce vůdčích aptských až valanginských druhů v základních jednotkách Západních Karpat na území České a Slovenské republiky.

Stages		Zones (Reboulet et al., 2018)	Outer W. Carpathians – Silesian Unit	Pieniny Klippen Belt	Central W. Carpathians
APTIAN	Upper	*Hypacanthoplites jacobi*			
		Acanthohoplites nolani	*Acanthohoplites nolani exiquecostatus*		
		Parahoplites melchioris			
		Epicheloniceras martini			
	Lower	*Dufrenyoia furcata*			
		Deshayesites deshayesi			
		Deshayesites forbesi	*Paradeshayesites weissiformis*		
		Deshayesites oglanensis	*Procheloniceras albrechtiaustriae*		*Deshayesites ex gr. involutus*
BARREMIAN	Upper	*Martellites sarasini*	*Pseudohaploceras liptoviense*	*Pseudohaploceras liptoviense*	
		Imerites giraudi	*Silesites seranonis*	*Silesites seranonis*	
		Gerhardtia sartousiana	*Costidiscus recticostatus* *Gerhardtia* cf. *provincialis*		*Costidiscus recticostatus*
		Toxancyloceras vandenheckii			*Toxancyloceras vandenheckii*
	Lower	*Moutoniceras moutonianum*			
		Kotetishvilia compressissima	*Kotetishvilia* cf. *compressissima* *Hamulinites parvulus*		*Kotetishvilia compressissima* *Holcodiscus decorus* *Avramidiscus gastaldianus* *Hamulinites parvulus*
		Nicklesia pulchella	*Nicklesia pulchella*		
		Kotetishvilia nicklesi			
		Taveraidiscus hugii	*Hamulina lorioli*		*Hamulina lorioli* *Taveraidiscus* cf. *hugii*

HAUTERIVIAN	Upper	*"Pseudothurmannia ohmi"*			*Pseudothurmannia (Kakabadziella) ohmi*
		Balearites balearis		*Binelliceras binelli*	*Balearites balearis* *Discoidellia mariolae* *Binelliceras binelli*
		Plesiospitidiscus ligatus	*Euptychoceras* cf. *subundulatum*		*Discoidellia pouponi* *Euptychoceras subundulatum* *Euptychoceras meyrati* *Plesiospitidiscus ligatus*
		Subsaynella sayni		*Subsaynella sayni*	*Abrytusites thieuloyi* *Subsaynella mimica*
	Lower	*Lyticoceras nodosoplicatum*		*Abrytusites julianyi*	*Lyticoceras nodosoplicatum* *Olcostephanus variegatus*
		Crioceratites loryi			*Jeannoticeras jeannoti*
		Acanthodiscus radiatus		*Tescheniceras flucticulum*	*Leopoldina cf. leopoldi* *Spitidiscus ex gr. rotula* *Tescheniceras flucticulum*
VALANGINIAN	Upper	*Criosarasinella furcillata*	*Tescheniceras pachydicranum*	*Himantoceras trinodosum*	*Tescheniceras flucticulum* *Tescheniceras pachydicranum* *Tescheniceras callidiscum* *Himantoceras trinodosum* *Criosarasinella furcillata*
		Neocomites peregrinus			*Olcostephanus nicklesi* *Neocomites* cf. *peregrinus* *Dichotomites evolutus*
		Saynoceras verrucosum		*Valanginites* cf. *nucleus*	*Valanginites bachelardi* *Olcostephanus atherstoni*
	Lower	*Karakaschiceras inostranzewi*	*Busnardoites campylotoxus*		*Busnardoites campylotoxus*
		Neocomites neocomiensiformis	*Platylenticeras pseudograsianum* *Neocomites neocomiensiformis*		*Neocomites neocomiensiformis*
		"Thurmanniceras" pertransiens	*Vergoliceras salinarium* *"Thurmanniceras"–pertransiens*		*Vergoliceras salinarium*
B.	U.	*Tirnovella alpillensis*			*Spiticeras simplicostatum*

and *Platylenticeras pseudograsianum* all originate from this part. No ammonites date lower part of late Valanginian. In contrast, during latest Valanginian, there were numerous ammonites of the genus *Tescheniceras* Vašíček, 2020, for example *T. pachydicranum* (Thieuloy) and ?*T. scioptychum* (Uhlig). Other species limited to the Hauterivian /excluding *Euptychoceras* cf. *subundulatum* (d'Orbigny) – originally *Ptychoceras teschenensis* Hohenegger/ – are not known in the Silesian Unit. Late Hauterivian and basal Barremian are recorded in the Silesian Unit in sandy flysch. Locally, a historical occurrence of shallow-water macrofauna without stratigraphically important ammonites is recorded in this part of the sequence (Ascher 1906).

Superposed deposits, corresponding with the name Wernsdorfer Schichten according to Hohenegger, are to these days abundant in ammonites. Ammonites occur in isolated horizons of dark grey claystones and marlstones, and exceptionally also in clayey ironstone. Ammonites determined by Hohenegger (1861) and taxonomically elaborated by Uhlig (1883) indicate the whole Barremian to the early Aptian. Vašíček (1981) also found another upper Aptian horizon with ammonites. In these deposits, over one hundred species have been described to date. As their numbers are overwhelming, only a selection of the most typical ones is listened below. Species belonging to the same genus or those that are of a minor stratigraphic importance have been omitted. Representatives of Phylloceratina and Lytoceratina suborders have not been included, with the exception of three significant species of the Lytoceratina suborder.

In the early Barremian, the following species occur: *Hamulina lorioli* (Uhlig), *Silesites vulpes* (Coquand), *Nicklesia pulchella* (d'Orbigny), *Kotetishvilia* cf. *compressissima* (d'Orbigny), *Holcodiscus* cf. *angulatus* Tzankov, *Barremites psilotatus* (Uhlig) and, in particular, a considerable number of heteromorph ammonites: *Leptoceratoides pumilus* (Uhlig), *L. subtilis* (Uhlig), *Karsteniceras beyrichoide* Vašíček and Wiedmann, *Hamulinites parvulus* (Uhlig), *Eoheteroceras uhligi* (Vašíček), *Josticeras wiedmanni* Vašíček, *Manoloviceras saharievae* Vašíček and Wiedmann, *Hamulina astieriana* d'Orbigny, *Amorina hoheneggeri* (Uhlig), *A. victoruhligi* Vermeulen and Vašíček, 2011. The range of late Barremian species and genera is similar: *Silesites seranonis* (d'Orbigny), *Gerhardtia* cf. *provincialis* (d'Orbigny), *Haplobrancoceras subquadratum* Avram, *Barremitites strettostoma* (Uhlig), *Pseudohaploceras liptoviense* (Zeuschner), *Macroscaphites yvani* (Puzos), *M. recticostatus* (d'Orbigny) and frequent heteromorph species *Spinocrioceras amadei* (Uhlig), *Audouliceras fallauxi* (Uhlig), *Barrancyloceras hammatoptychum* (Uhlig), *Artareites karsteni* (Uhlig), *Leptohamulina rothi* Vašíček, *Ptychohamulina ptychoceratoides* (Uhlig), *Ptychoceras puzosianum* d'Orbigny, *Lytocrioceras* cf. *jauberti* (Astier), *Argvethites* sp. and others. The early Aptian is characterised by the species *Procheloniceras albrechtiaustriae* (Uhlig), *P. pachystephanum* (Uhlig), *Deshayesites beskidensis* (Uhlig), *Paradeshayesites weissiformis* (Bogdanova) and *Toxoceratoides karstenioides* Vašíček and Skupien. *Barremitites strettostoma* and *Pseudohaploceras liptoviense* starting to appear in the late Barremian still occur here. Upper Aptian ammonites were found in one locality: *Acanthohoplites nolani exiquecostatus* Egoian, *Nodosohoplites moravicus* Vašíček, *N. difficilis* Vašíček and *Tetragonites duvalianus* (d'Orbigny).

4. PIENINY KLIPPEN BELT

Valanginites cf. *nucleus* (Roemer) in the Revišné locality (in the Orava river basin near Veličné) is the stratigraphically oldest findings in the Pieniny Klippen Belt. *Criohimantoceras gigas* Thieloy and *Himantoceras trinodosum* Thieuloy were found there as well (tab. 1). In addition, *Himantoceras trinodosum* (Skupien *et al.* 2003) was found in the Na Dlhej Quarry (near Horné Srnie). This species corresponds with the deposits around the borders of the Peregrinus and Furcillata Zones, including the lower part of the latest Valanginian ammonite Furcillata Zone. More frequent, stratigraphically younger ammonites are mostly

found in the Podbranč (Podmajeričky) locality in a more extensive sequence (Vašíček 2002). The younger ammonites, e.g. *Tescheniceras* are contained in the deposits around the Valanginian/Hauterivian boundary. Following the most recent findings in Pieniny Klippen Belt (Vašíček 2020 b), the spread of this ammonite in the Western Carpathians is the uppermost Valanginian to the lowest Hauterivian. According to professional papers, *Oosterella ondulata* Reboulet and *Jeanthieuloyites nodosus* (Mandov) have a similar distribution. In the upper part of the early Hauterivian in the Podbranč locality *Abrytusites julianyi* (Honnorat-Bastide) finally appears. The beginning of the late Hauterivian is indicated by zonal *Subsaynella sayni* Paquier, and even a higher part of the Hauterivian (the ?Ligatus Zone) is indicated by *Euptychoceras meyrati* (Ooster). The uppermost Hauterivian (the Balearites Zone) is indicated by numerous specimens of *Binelliceras binelli* (Astier). Overburden sequence indicates only the late Barremian: barremitids, *Silesites seranonis* (d'Orbigny) and a single specimen of *Hemihoplites soulieri* (Matheron), unknown in other Western Carpathian localities. This category also includes an older finding without a more precise localisation *Pseudohaploceras liptoviense* (Zejszner) from the Podbiel locality deposited in the collections of the State Dionýz Štúr Geological Institute in Bratislava, Slovakia.

5. CENTRAL WESTERN CARPATHIANS

The oldest ammonites in the Early Cretaceous sequence in the Butkov Quarry starting with the Ladce Formation sporadically appear around the border of the Berriasian/ Valanginian zones – *Spiticeras simplicostatus* Nikolov and *Clavithurmannia* cf. *foraticostata* Thieuloy. Several species of partially zonal importance originate from the early Valanginian: *Olcostephanus drumensis* (Kilian), *Vergoliceras salinarium* (Uhlig), *Busnardoites campylotoxus* (Uhlig), *Neocomites neocomiensiformis* (Uhlig) and *Kilianella clavicostata* Nikolov. *Olcostephanus atherstoni* (Sharpe) – until recently = *O. guebhardi* Kilian (in Mourgues *et al.* 2015) – and *O. tenuituberculatus* Bulot occur around the transition of the early/late Valanginian. It is notable that the leading genus, *Karakaschiceras* Thieuloy, is not present here. A sole specimen of *Neocomites* cf. *peregrinus* (Rawson and Kemper) was found in the late Valanginian Peregrinus Zone; *Rodighieroites cardulus* Company is there more frequent, *Dichotomites evolutus* Kemper, *Valanginites bachelardi* (Sayn) and *Oosterella* cf. *vilanovae* (Nicklés) occur sporadically. *Himantoceras trinodosum* Thieuloy, *Criosarasinella furcillata* Thieuloy, *C. mandovi* Thieuloy, *Olcostephanus nicklesi* Wiedmann and Dieni, *O. densicostatus* (Wegner), *Jeanthieuloyites nodosus* (Mandov), *Oosterella cultrataeformis* (Uhlig), *Bochianites neocomiensis* (d'Orbigny), *Crioceratites heterocostatus* Mandov, *C. coniferus* Busnardo, *Tescheniceras callidiscum* Thieuloy), *T. pachydicranum* (Thieuloy) and *T. subflucticulum* (Reboulet) occur in the uppermost Valanginian (the Peregrinus and Furcillata Zones).

The Ladce Formation weaves through the Mráznica Formation in multiple, finger-like layers. This transient segment contains the border between the Valanginian and the Hauterivian. *Spitidiscus* cf. *rotula* (Sowerby), *S. meneghinii* (Rodighiero), *Teschenicas flucticulum* (Thieuloy), *Leopoldia* cf. *leopoldina* (d'Orbigny), *Sarasinella subdensicostata* Vašíček, *Parastieria* cf. *hispanica* (Mallada), and *Bochianites oosteri* Sarasin and Schöndelmayer occur in the basal Hauterivian (the Radiatus Zone). The zonal species *Acanthodiscus radiatus* (Bruguiére) and subzonal species *Breistrofferella castellanensis* (d'Orbigny) are unknown. The Hauterivian base is indicated here by the first occurrence of genus *Spitidiscus* (Vašíček and Klein 2021). The higher early Hauterivian is indicated by extremely rare occurrences of *Jeannoticeras jeannoti* (d'Orbigny), *Plesiospitidiscus fasciger* (Thieuloy), *Lyticoceras nodosoplicatum* (Kilian and Reboul), *L. kiliani* Reboulet and Atrops, and *Olcostephanus variegatus* (Paquier).

The Mráznica Formation merges into the Kališčo Formation at the end of the early Hauterivian. *Subsaynella mimica* Thieuloy and Bulot and *Abrytusites thieuloyi* Vašíček and Michalík sporadically occur on the base of the late Hauterivian (the Sayni Zone). The following zone of the late Hauterivian (the Ligatus) is well indicated by the more frequent occurrence of *Plesiospitidiscus ligatus* (d'Orbigny), accompanied by *A. thieuloyi*. *Euptychoceras meyrati* (Ooster), *E. subundulatum* (d'Orbigny), and very rarely, the first representatives of pulchelliid ammonites *Discoidellia pouponi* Vermeulen and *D. couratieri* Vermeulen occur near the border between the Ligatus and the Balearis Zones in the upper part of the Kališčo Formation (between the Kališčo Formation and the Lúčková Formation). *Binelliceras binelli* (Astier), *B. ibizense* (Wiedmann), *Discoidellia mariolae* (Nicklès), *Plesiospitidiscus* cf. *canalis* Busnardo et al. and further *E. subundulatum* (d'Orbigny) occur in the Lúčková Formation (the Balearis Zone). In the final parts of the Hauterivian sections, fragments of *Barremites* cf. *primitivus* Cecca et al. can be found.

The ammonites from the quarries near Lietavská Lúčka hold an exceptional position in the sequence around the Hauterivian/Barremian boundary. In its lower part, *Plesiospitidiscus ligatus* occurs, indicating an eponymous ammonite zone. It is accompanied by *E. subundulatum* (Ooster), *Acrioceras pulcherrimum* (d'Orbigny), *Subaspinoceras mulsanti* (Astier). *E. subundulatum* continues on the base of the following Balearis Zone. Deposits in this zone are rich in ammonites, particularly of the *Binelliceras* and *Balearites* genera: *Binelliceras binelli* (Astier), *B. ibizensis* (Wiedmann), *B. michalíki* Vašíček and Malek, *B. rotundatus* Hoedemaeker, *Balearites balearis* (Nolan), *B. shankariae* Sarkar and *B. theodomirensis* Hoedemaeker. The latest Hauterivian (the Ohmi Zone) age is indicated by *Pseudothurmannia (Kakabadziella) ohmi*. In the overburden deposits around the Hauterivian/Barremian boundary *Hamulina lorioli* (Uhlig) and *Hamulinites parvulus* (Uhlig) sporadically occur, and *Taveraidiscus* cf. *hugii* (Ooster) can be found on the base of the Barremian.

Early Barremian sequence in the Butkov Quarry starts with deposits with only isolated findings of ammonites, comprising *Kotetishvilia compressissima* (d'Orbigny), *Dissimilites dissimilis* (d'Orbigny), *Moutoniceras nodosum* (d'Orbigny), *Patruliusiceras lateumbilicatum* Avram and rich associations of the holcodiscid species, such as *Holcodiscus decorus* Avram, *Parasaynoceras tzankovi* (Avram), *P. butkoviensis* Vašíček, *Avramidiscus gastaldianus* (d'Orbigny), *Metahoplites misiki* Vašíček and others (Vašíček 2006).

In the late Barremian, the zone species *Toxancyloceras vandenheckei* (Astier) sporadically occurs, along with a single specimen of *Costidiscus recticostatus* (d'Orbigny). Fossiliferous sequence is topped by an abundant occurrence of poorly preserved barremitid ammonites followed by an ammonite-free Urgon facies.

The early Aptian *Deshayesites* ex gr. *involutus* Spath (Vašíček *et al.* 1983) has been found in a single Horná Poruba locality in the Strážovská Hornatina Upland.

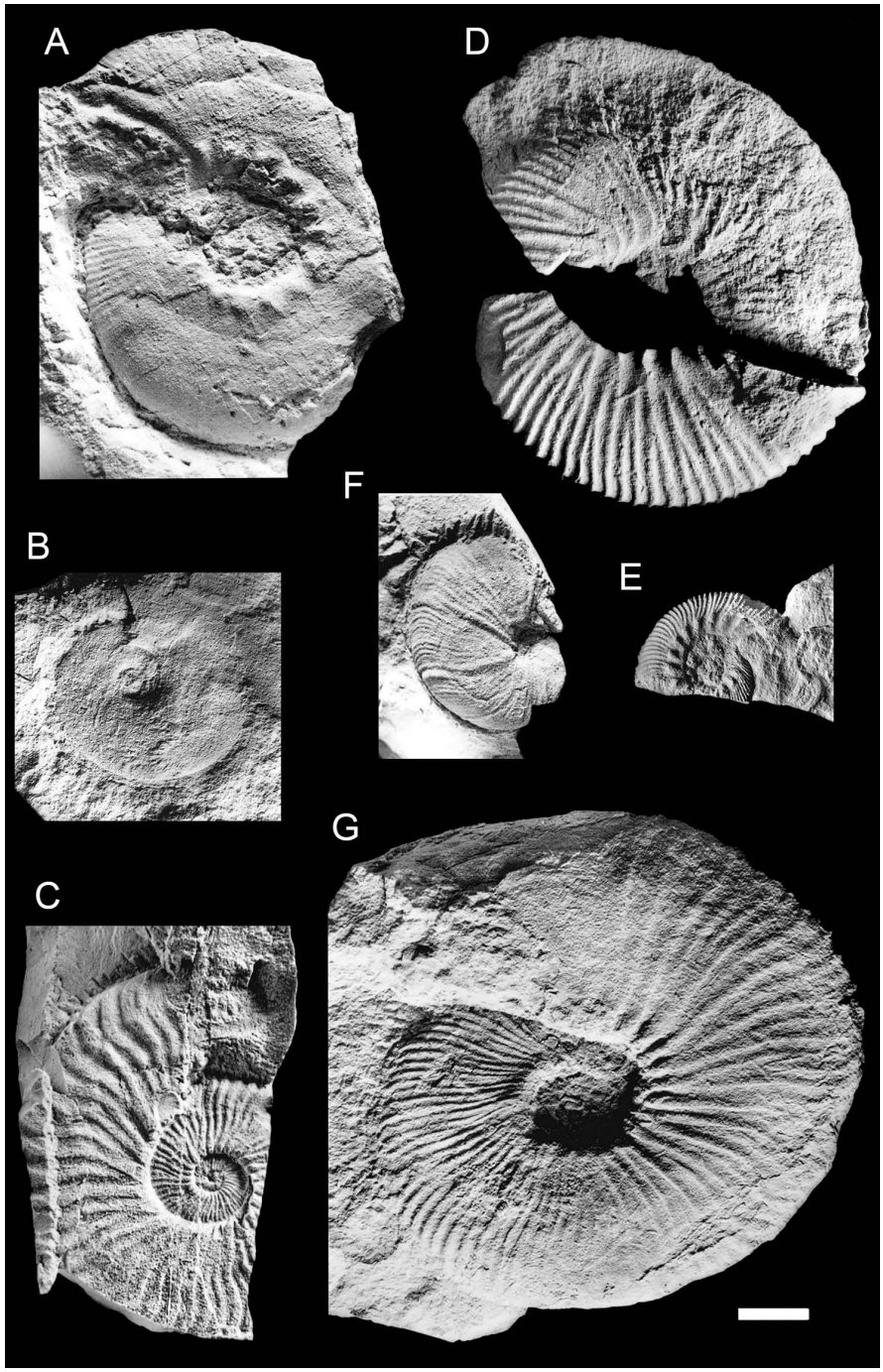
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Fig. 3. A) *Olcostephanus drumensis* (Kilian, 1910), spec. BK10/11-20. Butkov Quarry, Central Western Carpathians, exit road from the Level 10 to Level 11 near the Sanctuarium; base of the Ladce Formation, early Valanginian („Thurmanniceras" pertransiens ammonite Zone). Photo from Vašíček (in prep.). B) *Vergoliceras salinarium* (Uhlig, 1888), spec. BK10/11B-3. Butkov Quarry, higher part of the exit road from Level 10 to Level 11; transition of the Ladce Formation to the Mráznica Formation, early Valanginian („Thurmanniceras" pertransiens Zone). Older find without former publication. C) *Busnardoites campylotoxus* (Uhlig, 1902), spec. BK10-0/11. Butkov Quarry, Level 10, the 0 m level; transition of the Ladce Formation to the Mráznica Formation, early Valanginian (Karakaschiceras inostranzewi Zone). Photo from Vašíček (2010). D) *Dichotomites (Dichotomites) evolutus* Kemper, 1978, spec. BK10-13,5/3. Butkov Quarry, Level 10, the 13.5 m level; Mráznica Formation, late Valanginian (Neocomites peregrinus Zone). Photo from Vašíček (2010). E) *Olcostephanus nicklesi* Wiedmann and Dieni, 1968, spec. BK11-29/17. Butkov Quarry, Level 11, the 29 m level; Mráznica Formation, late Valanginian (the basal part of Criosarasinella furcillata Zone). Photo from Vašíček (2010). F) *Spitidiscus* ex gr. *rotula* (Sowerby, 1827), spec. BK10-105/1. Butkov Quarry, Level 10, the 105 m level; Mráznica Formation, early Hauterivian (Crioceratites loryi Zone). Photo from Vašíček and Klein (2021). G) *Teschenicerasflucticulum* Thieuloy, 1977, spec. without number. Podbiel, Pieniny Klippen Belt; Mráznica Formation, base of the early Hauterivian (Acanthodiscus radiatus Zone). Older find without former publication. Scale bar 10 mm.

Obr. 3. A) *Olcostephanus drumensis* (Kilian, 1910). Lom Butkov, Centrální Západní Karpaty, výjezd z 10. na 11. etáž v těsné blízkosti sanktuária; báze ladeckého souvrství, raný valangin (amonitová zóna „Thurmanniceras" pertransiens – amonitové zóny podle Reboulet *et al.* 2018). Foto z příspěvku Vašíček (in prep.). B) *Vergoliceras salinarium* (Uhlig, 1888). Lom Butkov, vyšší část výjezdu z 10. na 11. etáž; přechodné uloženiny ladeckého souvrství do souvrství mráznického, raný valangin (amonitová zóna „Thurmanniceras" pertransiens). Starší dosud nepublikovaný nález. C) *Busnardoites campyloxus* (Uhlig, 1902), lom Butkov, 10. etáž na počátku profilu (úroveň 0 m); přechod ladeckého souvrství do souvrství mráznického, raný valangin (zóna Karakaschiceras inostranzewi). Foto Vašíček (2010). D) *Dichotomites* (*Dichotomites*) *evolutus* Kemper, 1978. Lom Butkov, 10. etáž, úroveň 13,5 m na profilu); mráznické souvrství, pozdní valangin (zóna Neocomites peregrinus). Foto Vašíček (2010). E) *Olcostephanus nicklesi* Wiedmann a Dieni, 1968. Lom Butkov, 11. etáž. Pozdní valangin (bazální část zóny Criosarasinella furcillata). Foto Vašíček (2010). F) *Spitidiscus* ex gr. (Sowerby, 1827). Lom Butkov, 10. etáž, 105 m na profilu; mráznické souvrství, raný hauteriv (zóna Crioceratites loryi). Foto Vašíček a Klein (2021). G) *Teschenicerasflucticulum* Thieuloy, 1977. Lokalita Podbiel, pieninské bradlové pásmo; mráznické souvrství, báze raného hauterivu (zóna Acanthodiscus radiatus). Starší dosud nepublikovaný nález. Měřítko 10 mm.

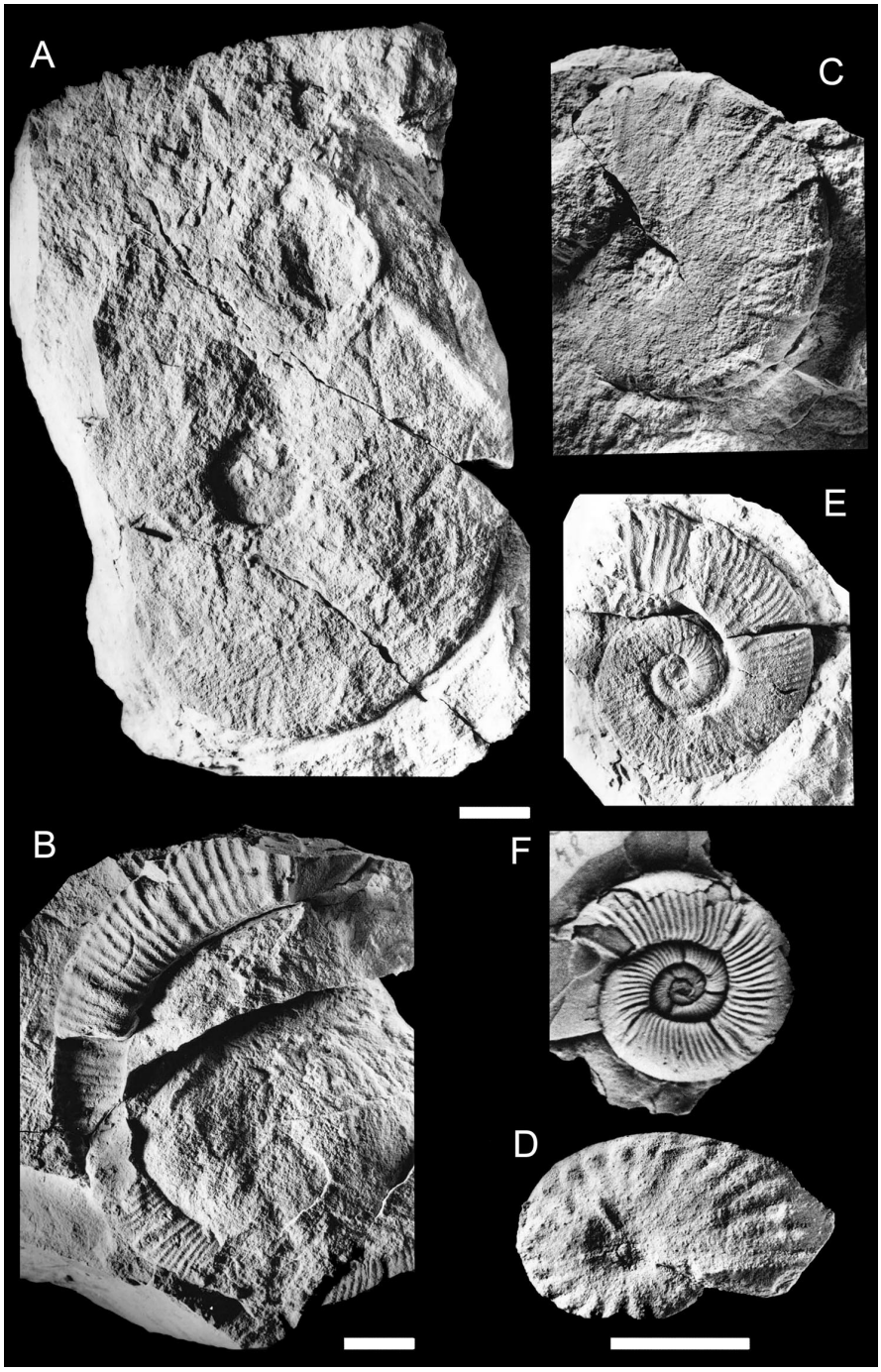
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Fig. 4. A) *Leopoldia* cf. *leopoldina* (D'ORBIGNY, 1840), spec. BK5-249/2. Butkov Quarry, Level 5, the 240 m level; Mráznica Formation, early Hauterivian (Acanthodiscus radiatus Zone). Photo Vašíček (in prep.). B) *Himantoceras trinodosum* Thieuloy, 1964, spec. BK11B-1. Butkov Quarry, Level 11, horizon P2; Mráznica Formation, late Valanginian (Criosarasinella furcillata Zone). Photo Vašíček (2005). C) *Plesiospitidiscus ligatus* (D'ORBIGNY, 1841), spec. BK7-90/debris. Butkov Quarry, Level 7, debris; Kališčo Formation, late Hauterivian (Plesiospitidiscus ligatus Zone). Older find without former publication. D) *Discoidellia mariolae* (NICKLÈS, 1890), spec. BK10-170/2. Butkov Quarry, Level 10, the 170 m level; Lúčková Formation, late Hauterivian (Balearites balearis Zone). Photo Vašíček (in prep.). E) *Binelliceras binelli* (ASTIER, 1851), spec. BK5-50/2. Butkov Quarry, Level 5, the 50 m level; Lúčková Formation (Balearites balearis Zone). Photo Vašíček (in prep). F) *Silesites seranonis* (D'ORBIGNY, 1841), spec. from the spoil heap near the village of Kozlovice. Silesian Unit; Hradiště Formation, late Barremian (Imerites giraudi Zone). Copy from Vašíček *et al.* (1994). Scale bar 10 mm with exception of 20 mm in the fig. D.

Obr. 4. A) *Leopoldia* cf. *leopoldina* (D'ORBIGNY, 1840). Lom Butkov. 5. etáž, 240 m; mráznické souvrství, raný hauteriv (zóna Acanthodiscus radiatus). Foto Vašíček (in prep.). B) *Himantoceras trinodosum* Thieuloy, 1964. Lom Butkov, 11. etáž, horizont P; mráznické souvrství, pozdní valangin (zóna Criosarasinella furcillata). Foto Vašíček (2005). C) *Plesiospitidiscus ligatus* (D'ORBIGNY, 1841). Lom Butkov, 7. etáž suť; kališčianské souvrství, pozdní hauteriv (zóna Plesiospitidiscus ligatus). Starší dosud nepublikovaný nález. D) *Discoidellia mariolae* (NICKLÈS, 1890). Lom Butkov, 10. etáž, 170 m; lúčkovské souvrství, pozdní hauteriv (zóna Balearites balearis). Foto Vašíček (in prep.). E) *Binelliceras binelli* (ASTIER, 1851). Lom Butkov, 5. etáž, 50 m; lúčkovské souvrství, pozdní hauteriv (zóna Balearites balearis). Foto Vašíček (in prep.). F) *Silesites seranonis* (D'ORBIGNY, 1841). Halda po těžbě pelosideritů u obce Kozlovice. Slezská jednotka, hradištské souvrství, pozdní barrem (zóna Imerites giraudi). Kopie z Vašíček *et al.* (1994). Měřítko 10 mm s výjimkou 20 mm u obr. D.

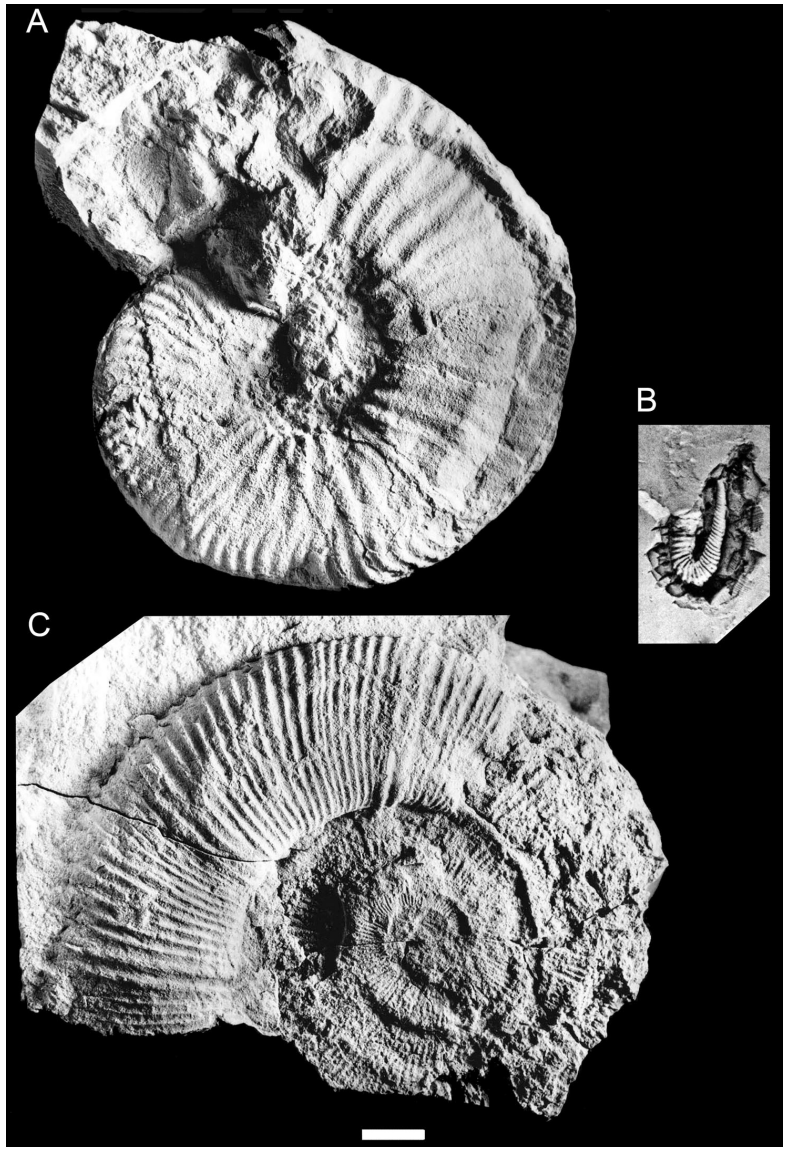

Fig. 5. A) *Lyticoceras nodosoplicatum* (Kilian and Reboul, 1915), spec. BK7C-13. Butkov Quarry, Level 7, horizon 13; Mráznica Formation, upper part of the early Hauterivian (Lyticoceras nodosoplicatum Zone). Photo Vašíček (in prep.). B) *Hamulinites parvulus* (Uhlig, 1883), spec. from outcrop in the Lubina River near the village of Trojanovice. Silesian Unit; Hradiště Formation, early Barremian (Kotetishvilia compressissima Zone). Copy from Vašíček *et al.* (1994). C) *Costidiscus recticostatus* (d'Orbigny, 1841), spec. BK3-155. Butkov Quarry, Level 3, the 155 m level; Lúčková Formation, late Barremian (Gerhardtia sartousiana Zone). Older find without former publication. Scale bar 10 mm.

Obr. 5. A) *Lyticoceras nodosoplicatum* (Kilian a Reboul, 1915). Lom Butkov, 7. etáž, horizont 7; mráznické souvrství, svrchní část raného hauterivu (zóna Lyticoceras nodosoplicatum). Foto Vašíček (in prep.). B) *Hamulinites parvulus* (Uhlig, 1883). Výchoz v říčce Lubina u obce Trojanovice. Slezská jednotka, hradištské souvrství, raný barrem (zóna Kotetishvilia compressissima). Kopie z Vašíček *et al.* (1994). C) *Costidiscus recticostatus* (d'Orbigny, 1841). Lom Butkov, 3. etáž, 155 m; lúčkovské souvrství, pozdní barrem (zóna Gerhardia sartousiana). Starší dosud nepublikovaný nález. Měřítko 10 mm.

Fig. 6. *Procheloniceras albrechtiaustriae* (HOHENEGGER in UHLIG, 1883), spec. from the outcrop in the Tichávka River near the village of Kunčice p. O. Silesian Unit; Hradiště Formation, early Aptian (Deshayesites oglanlensis Zone). Copy from Vašíček *et al.* (1994). Scale bar 10 mm.
Photos K. Mezihoráková (Ostrava). Specimens were coated with ammonium chlorite before photographing.

Obr. 6. *Procheloniceras albrechtiaustriae* (HOHENEGGER in UHLIG, 1883). Výchoz v říčce Tichávka u obce Kunčice pod Ondřejníkem. Slezská jednotka, hradištské souvrství, spodní apt (zóna Deshayesites oglanlensis). Kopie z Vašíček *et al.* (1994). Měřítko 10 mm.
Foto K. Mezihoráková (Ostrava). Exempláře byly před fotografováním běleny chloridem amonným.

6. DISCUSSION

Tab. 1 show distribution of selected number of only those ammonite species which belong to the current zonal species, or to species that used to be as index species, and other species of an index character occurring in the three or at least two of the tectonic units studied. Characteristic species are listed in the time sequence since the Valanginian until the Aptian and are correlated with the international ammonite zones according to Reboulet *et al.* (2018).

The initial look at the distribution of the Early Cretaceous ammonites reveals a notable difference, unevenness and incompleteness of the documented time span of the fossiliferous layers in the nappe units examined. The occurrence of ammonites is affected by development of the facies as well as by the complicated tectonic structure of each of the units examined. Some parts of the sequence have not been exposed in the field, or are non-fossiliferous. Due to considerable tectonic loading of the Carpathian rock bodies the observation of a continuous distribution of ammonite species allowing a reliable registration of the first (FO) and last occurrences (LO) of index species was not possible.

The Valanginian strata in the Pieniny Klippen Belt are only imperfectly indicated by ammonites. In contrast, the whole Valanginian sequence in the Central Carpathians is indicated by index ammonites. In the Silesian Unit, the same is true only about the early Valanginian. The uppermost Valanginian is indicated in the Silesian Unit after a long ammonite-free period. The Valanginian ammonite association of these units is dominated by the representatives of the Mediterranean bioprovince. An exception in the early Valanginian in the Silesian Unit is represented by a boreal element – genus *Platylenticeras* Hyatt and in the late Valanginian (the Peregrinus Zone) of the Slovakian Carpathians by sporadic occurrence of boreal genus *Dichotomites* Koenen.

Hauterivian ammonites are mostly missing in the Silesian Unit. Complete Hauterivian ammonite sequence is indicated in the Pieniny Klippen Belt, but being represented by few species only. The richest indication of the Hauterivian stage occurs in the Central Carpathians, including a range of zone or subzone species. Boreal elements are missing here.

The Silesian Unit of the Godula development in the Barremian and the early Aptian is extraordinary rich in ammonites. The ammonite association is dominated by heteromorphs ammonites. The early Aptian representation of *Procheloniceras* Spath and *Paradeshayesites* Kemper is significant. In the Pieniny Klippen Belt ammonites generally occur only sporadically, especially in the early Barremian. The Central Carpathian ammonites document early Barremian and, imperfectly, the late Barremian age, and very exceptionally the early Aptian age. Figs. 3–6 show examples of the zone or index species occurring both in the Silesian Unit, Pieniny Klippen Belt and also in Central Western Carpathians.

Carpathian Valanginian and the Hauterivian ammonite associations were located close to the Vocontian Basin of the Mediterranean ammonite bioprovince. Outer Western Carpathians was initially located at the edge of the West-European platform; the Silesian sediment area was the closest to this edge, while the Central Carpathian sedimentation area was the furthest. The Outer Western Carpathians from Central Western Carpathians was in the Cretaceous time separated by the Penninic Ocean.

The ammonite association of the Barremian and the early Aptian in the Silesian Unit of the Godula development differs from the Mediterranean bioprovince in comparison with the other two units. At the end of Barremian in the Central Western Carpathians occurred a lowering of sea level associated with sedimentation of shallow-marine limestones without ammonites (Michalík *et al.*, 2005). In the Silesian Unit the ammonite association in this period is dominated by phylloceratids and lytoceratids (over 50 %) and heteromorph ammonites (about 30 %) where the genus *Costidiscus* is strongly represented. The main reason probably being their different facial character.

7. CONCLUSION

Basic paleogeography following the occurrences of boreal ammonites in the Western Carpathians was studied by VAŠÍČEK a MICHALÍK (2002). RAWSON (1994) stated that the exchange of fauna between the Boreal and Mediterranean areas occurred in three stages via the Danish-Polish depression. The first event took place during early Valanginian ammonite Pertransiens Zone and at the start of the Neocomiensiformis Zone. This event was connected to the occurrence of the genus *Platylenticeras* known only in the Silesian Unit. The second event is associated with the late Valanginian Verrucosum Zone and with the lower part of the Peregrinus Zone. Some important Mediterranean elements (e.g. *Valanginites* and *Criohimantoceras* Thieuloy) have migrated in opposite direction (from west to east) to the Boreal region. In the Central Carpathians this boreal event is documented with *Dichotomites* and *Neocomites* cf. *peregrinus*. The third, early Hauterivian boreal expansion connected with the occurrence of the genus *Endemoceras* is not reliably documented in the Western Carpathians. At the end of Barremian there is a lowering of sea level associated with sedimentation of shallow marine limestones (MICHALÍK *et al.* 2005). Later, such communication has been interrupted.

In the early Aptian in the Silesian Unit, *Prochelonicerasalbrechtiaustriae* and *Paradeshayesites weissiformis*, sometimes considered as boreal elements, show zonal character. However, the mentioned genera originate from the Mediterrnean and Caucasian Realms, when the communication between Carpathian and the boreal zone did not exist.

SOUHRN

Severovýchodní část České republiky a převážná část přilehlého Slovenska náleží k soustavě Západních Karpat. V období spodní křídy k nim patří slezská jednotka ve vnějších (flyšových) Západních Karpatech, pieninské bradlové pásmo a Centrální Západní Karpaty na Slovensku. Západní Karpaty se vyznačují příkrovovou stavbou se složitou alpinotypní tektonikou komplikující biostratigrafický výzkum. Z litostratigrafického hlediska spodnokřídové uloženiny v godulském vývoji náležejí do kategorie tzv. černé křídy, slovenské jednotky převážně k facii biancone.

V předložené práci zhruba na základě šededesátiletého terénního výzkumu autora ve výše uvedených tektonostratigrafických jednotkách jsou analyzovány paralelní výskyty zónových, resp. vůdčích spodnokřídových amonitů v souladu s údaji REBOULETA *et al.* (2018). Výskyty vůdčích amonitů v Západních Karpatech znázorňuje tab. 1, příklady vyobrazených vůdčích amonitů dokládají fig. 3 až 6. Údaje o sporadickém výskytu vůdčích amonitů ve valanginu a hauterivu slezské jednotky se mimořádně opírají především o historické sběry Hoheneggera, taxonomicky později zpracované UHLIGEM (1902). Zajímavý je zde zejména záznam o výskytu spodnovalanginského boreálního amonita *Platylenticeras pseudograsianum*, který je na slovenských lokalitách neznámý. V uloženinách barremu až raného aptu slezské jednotky následuje hojný výskyt amonitů vůbec. V bradlovém pásmu je celkově výskyt amonitů ojedinělý. Raný valangin, stejně jako raný barrem tam doložen není. Komunikačním prvkem mezi bradlovým pásmem a Centrálními Karpatami na počátku pozdního valanginu je výskyt rodu *Valanginites*. Nejúplnější vrstevní sledy s výskytem vůdčích amonitů počínaje nejvyšším berriasem až do raného aptu jsou spojeny s lokalitami Centrálních Západních Karpat.

V závěru příspěvku jsou uvedeny údaje k paleogeografii studované oblasti, které generelně patří k mediteranní bioprovincii.

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REFERENCES

Andrusov, D., Samuel O., 1973: Cretaceous – Paleogene of the West Carpathians Mts. – Guide to Excursion E. X. Congress of Carpatho-Balcanian Geological Association, 3–78. Vyd. Geologický ústav Dionýza Štúra, Bratislava.

Ascher, E., 1906: Die Gastropoden, Bivalven und Brachiopoden der Grodischter Schichten. – Beitr. Paläont. Geol. Österr.-Ungarn Orients, 19, 135–172.

Borza, K., Michalík, J., Vašíček, Z., 1987: Lithological, biofacial and geochemical characterization of the Lower Cretaceous pelagic carbonate sequence of Mt. Butkov (Manín Unit, Western Carpathians). – Geol. Zbor. Geol. Carpath., 38, 3, 323–348.

Eliáš, M., Skupien, P., Vašíček, Z., 2003: Návrh úpravy litostratigrafického členění nižší části slezské jednotky na českém území (vnější Západní Karpaty). – Sbor. věd. Prací Vys. Šk. Báň. – Techn. Univ. Ostrava, Ř. horn.-geol., 49, Monografie 8, 7–13.

Hohenegger, L., 1861: Die geognostischen Verhältnisse der Nordkarpathen in Schlesien und den angrenzenden Theilen von Mähren und Galizien als Erläuterung zu der geognostischen Karte der Nordkarpathen. – Justus Perthes Verlag, Gotha, 1–50.

Klein, J., 2005: Lower Cretaceous Ammonites I – Perisphinctaceae 1, Himalayitidae, Olcostephanitidae, Holcodiscidae, Neocomitidae, Oosterellidae, pars 139. In Riegraf, W. (ed.) Fossilium Catalogus I: Animalia. Backhuys Publishers, Leiden, 1–484.

Michalík, J., Vašíček, Z. (eds.), Boorová, D., Golej, M., Halásová, E., Hort, P., Ledvák, P., Lintnerová, O., Měchová, L., Šimo, V. Šimonová, V., Reháková, D., Schlögl, J., Skupien, P., Smrečková, M., Soták, J., Zaharadníková, B., 2013: Vrch Butkov – kamenný archív histórie slovenských vrchov a druhohorného života. – Veda Editorial House, Bratislava, 1–164.

Michalík, J., Vašíček, Z., Skupien, P., Kratochvílová, L., Reháková, D., Halásová, E., 2005: Lower Cretaceous sequences of the Manín Unit (Butkov Quarry, Strážovské vrchy Mts., Western Carpathians) – integrated biostratigraphy and sequence stratigraphy. – Slovak Geological Magazine, 11, 1, 29–35.

Mourgues, F.A, Bulot, L. G., Frau, C., 2015: The Valanginian Olcostephaninae Haug, 1910 (Ammonoidea) from the Andean Lower Cretaceous Chañarcillo Basin, Northern Chile. – Andean Geol., 42, 2, 213–236.

Rawson, P. F., 1994: Sea level changes and their influence on ammonite biogeography in the European Early Cretaceous. – Palaeopelagos, Spec. Public., 1, 317–326.

Reboulet, S., Szives, O. (reps.), Aguirre-Urreta, B., Barragán, R., Company, M., Frau, C., Kakabadze, M. V., Klein, J., Moreno-Bedmar, J. A., Lukeneder, A., Pictet, A., Ploch, I., Raisossadat, S. N., Vašíček, Z., Baraboshkin, E. J., Mitta, V. V., 2018: Report on the 6th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Vienna, Austria, 20th August 2017). – Cret. Res., 91, 100–110.

Skupien, P., Vašíček, Z., Kratochvílová, L., 2003: Biostratigrafické výsledky ze studia tmavě zbarvených spodnokřídových pelitických uloženin v pieninském bradlovém pásmu (Západní Karpaty, Slovensko). – Sbor. věd. Pr. Vys. Šk. Báň. – Techn. Univ. Ostrava, Ř. horn.-geol., 49, Monografie 8, 135–151.

Uhlig, V., 1883: Die Cephalopodenfauna der Wernsdorfer Schichten. – Denkschriften kaiser. Akad. Wiss., math.-naturwiss. Cl., 46, 127–290.

Uhlig, V., 1902: Über die Cephalopodenfauna der Teschener und Grodischter Schichten. – Denkschriften kaiser. Akad. Wiss., math.-naturwiss. Cl., 72, 1–87.

Vašíček, Z., 1972: Ammonoidea of the Těšín-Hradiště Formation (Lower Cretaceous) in the Moravskoslezské Beskydy Mts. – Rozpr. Ústř. Úst. Geol., 38, 1–103.

Vašíček, Z., 1973 a: Zur Barreme-Apt-Grenze in der Schlesischen Einheit. – Sbor. věd. Pr. Vys. Šk. báň., Ř. horn.-geol., 18 (1972), 101–107.

Vašíček, Z., 1973 b: Über einige von V. Uhlig (1883) beschriebene Unterkreide-Ammoniten. – Sbor. geol. Věd, Paleont., 15, 49–73.

Vašíček, Z., 1975: Zur Revision der Ammoniten von den Oberen Těšín-Schichten (Valendis Stufe). – Sbor. geol. Věd, Paleont., 17, 71–107.
Vašíček, Z., 1981: Die Clansay-Ammoniten der höchsten Hradiště-Schichten (Silesische Einheit, Tschechoslowakei). – Sbor. věd. Pr. Vys. Šk. báň., Ř. horn.-geol., 25, 193–204.
Vašíček, Z., 1991: Hlavonožcová biostratigrafie spodnokřídových uloženin čsl. Západních Karpat. – DrSc. Dissertation, insets 1–27. Vysoká škola báňská, Ostrava, 1–138.
Vašíček, Z., 2002: Lower Cretaceous Ammonoidea in the Podbranč quarry (Pieniny Klippen Belt, Slovakia). – Bull. Czech geol. Surv., 77, 187–200.
Vašíček, Z., 2005: The oldest (Late Valanginian) Crioceratitinae (heteromorphic ammonoids) from the Central Western Carpathians (Slovakia). – Geol. Carpath., 56, 3, 245–254.
Vašíček, Z., 2006: A remarkable assemblage of Early Barremian ammonites in the Central Western Carpathians (Butkov Quarry, Slovakia). – Acta Geol. Pol., 56, 4, 421–440.
Vašíček, Z., 2008: Barremian and Early Aptian ammonites from the Godula Facies of the Silesian Unit in the Outer Western Carpathians, Czech Republic. – Acta Geol. Pol., 58, 4, 407–423.
Vašíček, Z., 2009: K současnému stavu poznání barremsko-aptských amonitů z godulské facie slezské jednotky v Moravskoslezských Beskydách (vnější Západní Karpaty, Česká republika). – Acta Mus. Beskid., 1, 59–78.
Vašíček, Z., 2010: Early Cretaceous ammonites from the Butkov Quarry (Manín Unit, Central Western Carpathians, Slovakia). – Acta Geol. Pol., 60, 3, 393–415.
Vašíček, Z., 2020 a: Early Cretaceus ammonites of the superfamily Bochianitoidea from the Butkov Quarry (Central Western Carpathians, Slovakia). – Neu. Jb. Geol. Paläont., Abh., 298/1, 75–85.
Vašíček, Z., 2020 b: *Teschenicerasgen.* nov. (Ammonoidea) and the definition of the Valanginian/Hauterivian boundary in Butkov Quarry (Central Western Carpathians, Slovakia). – Acta Geol. Pol., 70, 4, 569–584.
Vašíček, Z., in prep.: Sporadic Early Cretaceous ammonites from the Butkov Quarry (Central Western Carpathians, Slovakia). – Acta Geol. Pol.
Vašíček, Z., Klajmon, P., 1998: Contribution to the knowledge of small Early Barremian ammonites from the Silesian Unit (Outer Western Carpathians, Czech Republic). – Věst. Ústř. Úst. geol., 73, 4, 331–342.
Vašíček, Z., Klein, J., 2021: On imperfectly known Hauterivian representatives of the families Holcodiscidae Spath, 1923, and Barremitidae Breskovski, 1977 in Butkov Quarry (Central Western Carpathians, Slovakia). – Acta Geol. Pol., 71, 4, 433–451.
Vašíček, Z., Malek, O., 2017: Pseudothurmanniid ammonites from quarries near Lietavská Lúčka and their stratigraphical significance (Late Hauterivian, Central Western Carpathians, Slovakia). – Geol. Quart., 61, 3, 613–631.
Vašíček, Z., Michalík, J., 1986: The Lower Cretaceous ammonites of the Manín Unit (Mt. Butkov, West Carpathians). – Geol. Zbor. Geol. Carpath., 37, 4, 449–481.
Vašíček, Z., Michalík, J., 1988: Some heteromorphic ammonites from Polomec (Hauterivian-Barremian, Central Western Carpathians, Czechoslovakia). – Geol. Zbor. Geol. Carpath., 39, 6, 655–674.
Vašíček, Z., Michalík, J., 2002: Boreal elements in the Lower Cretaceous ammonite associations of the West Carpathian Tethyan sector. In Michalík, J. (ed.): Tethyan/Boreal Cretaceous Correlation. Mediterranean and Boreal Cretaceous paleobiogeographic areas in Central and Eastern Europe. – Veda, Bratislava, 115–136.
Vašíček, Z., Michalík, J., Borza, K., 1983: To the „Neocomian“ biostratigraphy in the Krížna-Nappe of the Strážovské vrchy Mountains (Northwestern Central Carpathians). – Zitteliana, 10, 467–483.
Vašíček, Z., Reháková, D., Michalík, J., Peterčáková, M., Halásová, E., 1992: Ammonites, aptychi, nanno- and mikroplankton from the Lower Cretaceous Pieniny Formation in the „Kysuca Gate“ near Žilina (Western Carpathian Klippen Belt, Kysuca Unit). – Západ. Karpaty, Sér. Paleont., 16, 43–57.
Vašíček, Z., Skupien, P., 2002: Notes on some rare Barremian/Aptian ancyloceratids from the Silesian Unit (Outer Western Carpathians, Czech Republic). – Journ. Czech geol. Soc., 47, 65–74.
Vašíček, Z., Skupien, P., Šulgan, F., 2004: New occurrences of Lower Cretaceous ammonites in the western part of the Silesian Unit (Barremian – Early Aptian, Outer Western Carpathians, Czech Republic). – Journ. Czech geol. Soc., 49, 41–55.
Vašíček, Z., Wiedmann, J., 1994: The Leptoceratoidinae: small heteromorph ammonites from the Barremian. – Palaeontology, 37, 1, 203–239.
Vermeulen, J., Vašíček, Z., 2011: Espèces d'ammonites nouvelles ou peu connues de la famille des Anahamulinidae Breistroffer, 1952 (Turrilitina, Ptychoceratoidea). – Ann. Mus. Hist. Natur. Nice, 26, 47–94.