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# Early Cretaceous ammonoid paleobiogeography of the West Carpathian part of the Paleoeuropean shelf margin

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With 7 figures

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**Abstract:** The diversity and distribution of ammonites in the Tithonian and Lower Cretaceous of the Western Carpathians reflects local paleogeography. Ammonites were more diversified on the European shelf from the Tithonian to the Valanginian, despite the preservational bias in the Central Carpathian sequences. This area was intermittently connected to the Boreal Realm by seaways, through which faunal migrations took place. By contrast, ammonite assemblages (purely Tethyan) of the Zliechov Basin on the Alpine Carpathian microplate displayed maximum diversity in the Hauterivian. The most diverse Barremian and Aptian ammonite associations are found in the Godula Basin. Albian ammonites were relatively rare and only known from the borders of the Penninic Oceanic Trough.

**Zusammenfassung:** Die Diversität und Verbreitung der Ammoniten im Tithon und in der Unterkreide der Westkarpaten spiegelt die lokale Paläogeographie wider. Trotz schlechter Erhaltungsbedingungen in den Zentralkarpaten erreichten Ammoniten auf dem europäischen Schelf vom Tithon bis zum Valangin die höchste Diversität. Dieses Gebiet war zeitweilig mit dem borealen Bereich durch Meeresstraßen verbunden, durch die Faunenmigrationen ermöglicht wurden. Im Gegensatz dazu erreichen die rein tethyalen Ammonitenfaunen des Zliechov-Beckens auf der Alpin-Karpathen-Mikroplatte ihr Diversitätsmaximum im Hauterive. Die höchstdiversen Ammonitengemeinschaften des Barreme und Apt werden im Godula-Becken beobachtet. Ammoniten des Alb sind relativ selten und nur von den Rändern des Penninischen Ozeanbeckens bekannt.

## Introduction

This paper presents the results of several years of stratigraphic and paleobiogeographic research in the Western Carpathians, where ammonites are

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the most abundant elements of the Lower Cretaceous macrofauna. Until 1993, we collaborated closely with Prof. Dr. JOST WIEDMANN, whose friendly approach and wide experience in ammonite systematics and palaeobiogeographic distribution helped us considerably to correlate the Western Carpathians sequences to those from other basins on a regional and intercontinental scale.

Cretaceous research has generally become more intensive during the last decade. The results of many studies have been presented at international symposia and workshops (4th Cretaceous Symposium in Hamburg 1992, 2nd Symposium on Cretaceous Stage Boundaries in Brussels 1995, Jost Wiedmann's Symposium in Tuebingen 1996, 5th Cretaceous Symposium in Freiberg 1996). Within the frame of IGCP Project No 362 "Tethyan and Boreal Cretaceous Correlation", numerous work meetings have also been organized (1993 in Coimbra, Portugal; 1994 in Smolenice, Slovakia; 1995 in Maastricht, The Netherlands; 1996 in Freiberg, Germany) and workshops (Lower Cretaceous Cephalopod Team – 1992: Digne; 1993: Mula; 1994: Piobbico; 1997: London). Cretaceous research in the Carpathians has benefited from the support of national research grants such as VEGA grant 1081, GACR 205/96/0753 etc.

The results of these meetings have led to numerous publications. In the last three years only, the following volumes have been published: Proceedings of the 4th International Cretaceous Symposium Hamburg 1992 (edited by C. SPAETH 1996), the Proceedings of the 3rd Workshop on Early Cretaceous Cephalopods (ed. by CECCA 1995), Lower Cretaceous Cephalopod Biostratigraphy of the Western Tethys (ed. by BULOT, ARGOT & ARNAUD 1995), as well as several important ammonite monographs (AUTRAN 1993, REBOULET 1996).

## General setting

The Mesozoic basinal systems of the Western Carpathians belong to two megaunits (Outer and Central West Carpathian blocks), which converged until the Turonian and collided during the early Miocene. The Outer Carpathian basins were formed by an extension of the East European (Fenno-Sarmatian) shelf foreland. By contrast, the Central Carpathians, which formed an integral part of the Mesozoic Alpine – Carpathian (= northern part of Jurassic – Cretaceous Apulian) microcontinent (MICHALÍK 1993, 1994b) were broken away from the North European shelf during the late Triassic. Jurassic and Early Cretaceous ESE movement of this block opened the Penninic Rift, but simultaneously closed the Meliata oceanic branch (MICHALÍK 1990).

Tensional stress in these crustal blocks formed a complex horsts and basins system, which influenced sea current patterns, plankton populations,

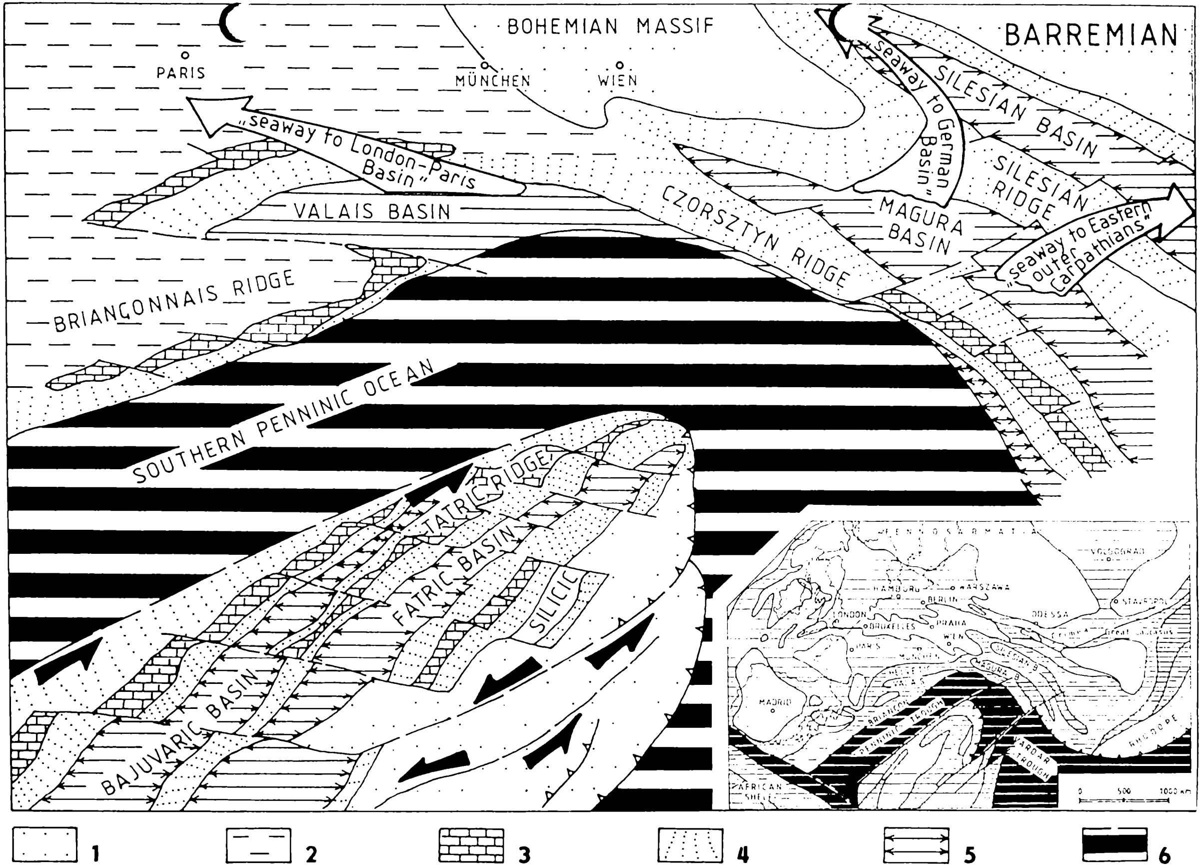


**Fig. 1.** Paleogeographic sketch of the Western Carpathians area during Barremian times. **1** - dry land, **2** - epicontinental sea, **3** - carbonate platforms, **4** - slope deposits, **5** - tensional basins, **6** - oceanic bottom.

and, thus, the character of the bio- and lithofacies (REHÁKOVÁ & MICHALÍK 1994, REHÁKOVÁ 1995a).

The Cretaceous position of the Western Carpathians in a northern edge-like embayment of the Mediterranean Tethys was special from the point of view of Tethyan/Boreal paleoclimatic and paleobiogeographic interactions (MICHALÍK 1995). During the Tithonian, Valanginian and early Hauterivian, several groups of marine organisms migrated from the Lower Saxony Basin to the Tethys and vice versa through the mouth of the Polish-Danian Trough (Fig. 1). These migrations modified the character of marine communities, especially so in the Outer Western Carpathian basins (VAŠÍČEK et al. 1994).

Upper Jurassic and Lower Cretaceous deposits form the Outer Carpathians usually form only the poorly preserved base of thick Paleogene flysch basins infillings, which are tectonically individualized into huge nappes. Only the southernmost border of the European shelf, which was affected by tensional movement along a huge strike-slip fault, was transformed into a complex structure of slices. This strike-slip fault, which contains large lenticular bodies of Mesozoic sedimentary rocks, is called the Pieniny Klippen Belt (PKB).

## Previous studies

Findings of ammonites were first reported from the Godula partial nappe of the Silesian Unit in the last century (HOHENEGGER 1855, 1861, UHLIG 1883, 1902). More recently, this fauna has been collected by VAŠÍČEK (1972, VAŠÍČEK et al. 1994). Lower Cretaceous cephalopods collected during the last four decades from the Baska development of the Silesian Unit were recently systematically studied (HOUŠA & VAŠÍČEK in print). The cephalopod fauna of the classical Lower Cretaceous localities of the Magura Basin which did not yield any ammonite shells, was described by REHÁKOVÁ et al. (1995) and ELIÁŠ et al. (1996).

Relatively rich ammonite associations from the Pieniny Klippen Belt collected since the last century (ZEUSCHNER 1856, NEUMAYR 1871) contain many poorly known forms. Although some have recently been studied (KUTEK & WIERZBOWSKI 1986, WIERZBOWSKI & REMANE 1992, WIERZBOWSKI 1994), a systematic revision is now desirable.

## Lower Cretaceous ammonite distribution

### Latest Tithonian – Berriasian

a) A rich biohermal Tithonian – earliest Cretaceous fauna (more than 600 known species in the white reefal Štramberk Limestone) dwelled on the Baška elevation NE of the Silesian Basin. However, cephalopods (ammonites, aptychi and belemnites), which belonged exclusively to the Mediterra-

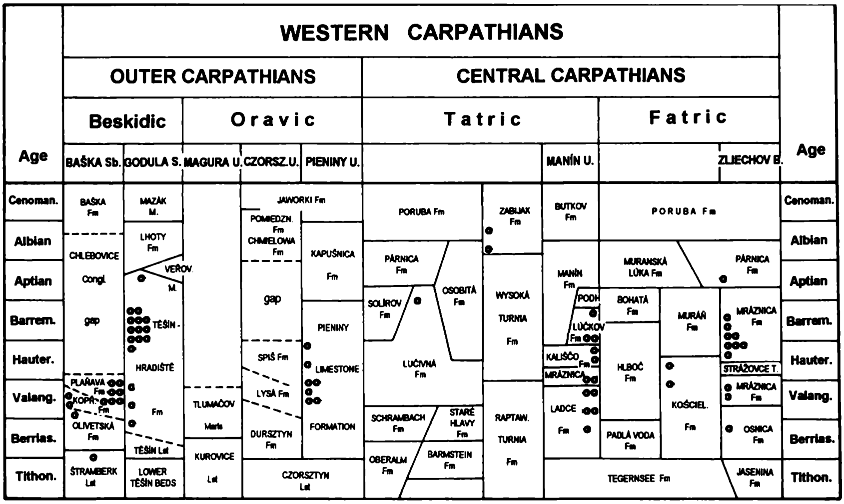


**Fig. 2.** Lithostratigraphic subdivision of the Lower Cretaceous in the northern part of the Western Carpathian units and their ammonite content: @ - ammonites, @@ - common ammonites, @@@ - rich in ammonites.

nean province, represent only a small proportion of the assemblage. ZITTEL (1868) described findings of berriasellid ammonites from white limestone olistolites in basinal deposits (Koňákov locality). Similar limestone olistolites with an ammonite fauna are known from the Romanian Eastern Carpathians (PATRULIUS & AVRAM 1976).

b) The major part of the Tithonian-Berriasian basinal infillings (so called "Godula development") in the Silesian Unit consists of dark brownish grey aleurolitic bituminous marls (Těšín Beds) with conglomeratic Ropice Horizon and calciturbiditic Těšín Limestone intercalations. Neither the Silesian- nor the neighbouring Magura Basin infillings contain any ammonites, with the exception of a few endemic, poorly preserved specimens.

c) Similarly, the infilling of the Magura Basin, preserved only in scarce tectonic slices, consists of calciturbidites (Kurovice Limestone) with greenish gray marls (Tlumačov Marl). The basal clastic part of calciturbidite rhythms contain redeposited biogene debris: crinoids, corals, fish teeth, along with clasts of older limestones and (more rarely) volcanic clasts. The higher part of the rhythmic sequences yielded graded remains of aptychi and rarely belemnites. Redeposited aptychi shells are the dominant constituents in the clastic base of the higher (upper Berriasian) turbidite rhythms.

| | | OUTER CARPATHIANS | |
|---|---|---|---|
| | | Silesian Unit | Pieniny Klippen Belt |
| | | Godula Subunit | Pieniny Unit |
| Aptian | Lower | *Deshayesites borowae, Phyllopachyceras baborense, Acrioceras karsteni, Cheloniceras aff. seminodosum, Procheloniceras pachycyclum, P. albrechtiaustriae* | |
| Barremian | Upper | *Pseudohaploceras liptoviense, Pseudosaynella strettostoma, Silesites seranonis, Ptychoceras dittleri, P. morloti, Argvethites* sp., *Macroscaphites yvani, Costidiscus recticostatus, C. olcostephanoides, Eulytoceras phestum, Spinocrioceras amadei, S. trachyomphalus, Anahamulina distans, Heinzia lindigi, H. provincialis* | |
| | Lower | *Silesites vulpes, Eoheteroceras uhligi, Hamulinites parvulus, Karsteniceras pumilum, Phyllopachyceras infundibulum, Eulytoceras anisoptychum, Barremites* sp., *Anahamulina hoheneggeri, A. ptychoceroides, Holcodiscus* ex gr. *caillaudianus, Nicklesia* cf. *pulchella, Hamulina astieriana, Paraspiticeras pachycyclum* | *Barremites* sp. |
| Hauterivian | Upper | | *Crioceratites binelli*<br>*Plesiospitidiscus* sp.<br>*Ptychoceras meyrati*<br>*Crioceratites* ex gr. *duvali*<br>*Subsaynella sani* |
| | Lower | *Endemoceras* cf. *amblygonium, Acanthodiscus* sp., *Breistrofferella* sp. | *Abrytusites thieuloyi*<br>*Bochianites oosteri, Olcostephanus jeannoti, Crioceratites nolani, Cr. loryi, Spitidiscus* cf. *rotula, Teschenites flucticulus, T.* cf. *castellanensiformis* |
| Valanginian | Upper | *Criosarasinella* cf. *furcillata, Prodichotomites* ex gr. *complanatus, Bochianites neocomiensis, Neocomites neocomiensis, N. teschenensis, Valanginites wilfridi, V.* ex gr. *nucleus, Saynoceras verrucosum* | *Oosterella* ex gr. *gaudryi, Jeanthieuloyites* sp., *Himantoceras trinodosum, Olcostephanus* cf. *detonii, Bochianites neocomiensis, Neolissoceras grasianum, Valanginites nucleus, Phyllopachyceras winkleri, Hypophylloceras thetys, Neocomites praediscus, N. platycostatus, N. teschenensis* |
| | Lower | *Protetragonites quadrisulcatus, Phylloceras serum, Hypophylloceras* ex gr. *thetys, Ptychophylloceras semisulcatum, Neolissoceras salinarium, N. grasianum, Platylenticeras* ex gr. *marcousianum, P. cardioceroides, Thurmanniceras thurmanni, Kilianella* ex gr. *roubaudiana* | |
| | | Baška Subunit | |

**Fig. 3.** Distribution of main ammonite species in ammonite-bearing formations of the Western Carpathians. In the upper part of the column, species coming from the Godula Subunit of the Barremian and Aptian are presented, while in the lower part, species from the Baška Subunit (Pláňava Formation) of the Valanginian and basal Hauterivian are given. Underlined genera are considered to be boreal elements.

| CENTRAL CARPATHIANS | | | |
|---|---|---|---|
| Tatric | Fatric | | |
| Manín Unit | Zliechov Subunit | | |
| | *Deshayesites* sp., *Cheloniceras* cf. *cornuelianum*,<br>*Costidiscus tenuistriatus*, *Macroscaphites striatisulcatus* | Lower | Aptian |
| *Costidiscus recticostatus* | *Silesites seranonis*,<br>*Costidiscus recticostatus*,<br>*Eulytoceras phestum*,<br>*Anahamulina* cf. *glemmbachensis* | Upper | Barremian |
| *Holcodiscus* ex gr. *perezianus*,<br>*Hamulinites* cf. *parvulus*, *Anahamulina* sp.,<br>*Valdedorsella uhligi*, *Barremites* sp., *Phyllopachyceras infundibulum*, *Psilotissotia favrei* | *Phyllopachyceras infundibulum*,<br>*Barremites* sp., *Silesites vulpes*,<br>*Hamulinites* cf. *parvulus*,<br>*Hamulina lorioli*,<br>*Veveysiceras escheri*,<br>*Spitidiscus* cf. *hugii*,<br>*Spitidiscus seunesi* | Lower | |
| *Crioceratites binelli*,<br>*Plesiospitidiscus* ex gr. *ligatus*,<br>*Spitidiscus fasciger*, *Ptychoceras meyrati*,<br>*Crioceratites* ex gr. *duvalii* | *Paraspiticeras* sp., *Anahamulina subcylindrica*,<br>*Pseudothurmannia mortilleti*, *Crioceratites majoricensis*,<br>*C. binelli*, *Pseudothurmannia shankariae*, *P. balearis*,<br>*Ptychoceras meyrati*, *Plesiospitidiscus* ex gr. *ligatus*,<br>*Acrioceras pulcherrimum*, *Crioceratites matsumotoi*,<br>*Subsaynella sayni* | Upper | Hauterivian |
| *Abrytusites thieuloyi*, *Bochianites oosteri*,<br>*Jeanthieuloyites nodosus*, *Crioceratites loryi*, *C. nolani*,<br>*Spitidiscus* ex gr. *rotula*, *S. cankovi*, *Lytoceras lepidum*,<br>*Eleniceras* ex gr. *tchechitevi* | *Olcostephanus hispanicus*<br>*Crioceratites nolani*<br>*Spitidiscus* ex gr. *rotula*<br>*Bochianites oosteri* | Lower | |
| *Techenites* ex gr. *neocomiensiformis*<br>*Teschenites subflucticulus*<br>*Criosarasinella heterocostata*<br>*Criosarasinella furcillata*<br>*Himantoceras trinodosum*<br>*Olcostephanus nicklesi*<br>*Neocomites teschenensis* | *Criosarasinella* ex gr. *mandovi*<br>*Neolissoceras grasianum*<br>*Bochianites neocomiensis*<br>*Himantoceras trinodosum*<br>*Protetragonites quadrisulcatus*<br>*Neocomites* ex gr. *neocomiensis*<br>*Neocomites teschenensis* | Upper | Valanginian |
| *Busnardoites campylotoxus*<br>*Neolissoceras salinarium* | | Lower | |
| | | | |

**Fig. 3** (continued)

d) Marginal elevations of the Pieniny Klippen Belt (PKB) were characterized by the Late Jurassic "Ammonitico Rosso" sedimentation of red nodular ammonite-rich limestones (Czorsztyn Limestone). During the late Tithonian (and until the Valanginian on topographic rises), this type of sedimentation was replaced by the accumulation of pelagic limestones of the "majolica" facies (Pieniny Limestone). These sediments contain rare berriasellid ammonites. More common finding of ammonites in the shallower Dursztyn Limestone, were reported by WIERZBOWSKI & REMANE (1992): *Berriasella* cf. *privasensis* (PICTET), *Spiticeras (S.)* aff. *groteanum* (OPPEL), *Neocosmoceras* sp.

## Valanginian

Berriasian deposits are generally poor in ammonites in the whole Western Carpathians. Ammonite diversity increased after the late Berriasian and earliest Valanginian (VAŠÍČEK et al. 1994, VAŠÍČEK & WIEDMANN 1994, VAŠÍČEK 1995a, b, HOUŠA & VAŠÍČEK in print) – Figure 2.

a) On the Baška Ridge, greenish marly (Olivetská Formation), reddish detrital limestones (Kopřivnice Formation), or dark grey pelites gradually replaced biohermal carbonates. Ammonites were recovered from redeposited reef/slope deposits included in the Stramberg Limestone Fm in the Štramberk area. They cannot be collected by a bed-by-bed method, and their age determination is supported by data from the literature (HOUŠA & VAŠÍČEK in print). However, the preservation of ammonite shells is rather poor and they are represented mostly by reworked internal and sculptural molds. Dark pelites contain usually pyrite molds of juvenile shells. Ammonites found with aptychi, belemnites and benthic organisms (bivalves, brachiopods, crinoids, echinoids, etc.) are represented by: *Thurmanniceras thurmanni* (PICTET & CAMPICHE), *T.* cf. *pertransiens* (SAYN), *Kilianella* ex gr. *roubaudiana* (D'ORBIGNY), *Platylenticeras* ex gr. *marcousianum* (D'ORBIGNY), *Pl. cardioceroides* (SAYN), *Neolissoceras salinarium* (UHLIG), *Karakaschiceras* ex gr. *quadristangulatum* (SAYN), *Protancyloceras* cf. *punicum* ARNOULD-

**Fig. 4.** Redeposited Valanginian and Early Hauterivian ammonites from the envelope formations of Štramberk Limestone bodies (Štramberk, Outer Carpathians, Silesian Unit, Baška Subunit).
**1-2**: *Neolissoceras salinarium* (UHLIG); **1** - lateral view, **2** - ventral view; Pláňava Formation, Early Valanginian, spec. 412/S54; × 1.4. **3**: *Platylenticeras* ex gr. *marcousianum* (D'ORBIGNY); Fragment of the adult whorl. Pláňava Formation, Early Valanginian, spec. 161/S12; × 0.7. **4**: *Kilianella* ex gr. *roubaudiana* (D'ORBIGNY); Pláňava Formation, Early Valanginian, spec. 216/S12; × 1.4. **5**: *Thurmanniceras thurmanni* (PICTET & CAMPICHE); Pláňava Formation, Early Valanginian, spec. 178/S45; × 0.7. **6-7**: *Protancycloceras* cf. *punicum* ARNOULD-SAGET; **6** – lateral view, **7** - ventral view. Olivetská Formation, Early Valanginian (?), spec. 223; × 2.1. **8-9**: *Saynoceras verrucosum* ( D'ORBIGNY); **8** - lateral view, **9** - ventral view; Pláňava Formation, Late Valanginian, spec. 429/S55; × 2.1. **10**: *Endemoceras* ex gr. *amblygonium* (NEUMAYR & UHLIG); Pláňava Formation, Early Hauterivian, spec. 418/S55; × 0.7. **11**: *Prodichotomites* ex gr. *complanatus* (KOENEN); deformed fragment. Pláňava Formation, Late Valanginian, spec. 436/S55; × 0.7. **12-13**: *Prodichotomites* ex gr. *complanatus* (KOENEN); **12** - lateral view, **13** - ventral view; Pláňava Formation, Late Valanginian, spec. 323/S44; × 2.1.

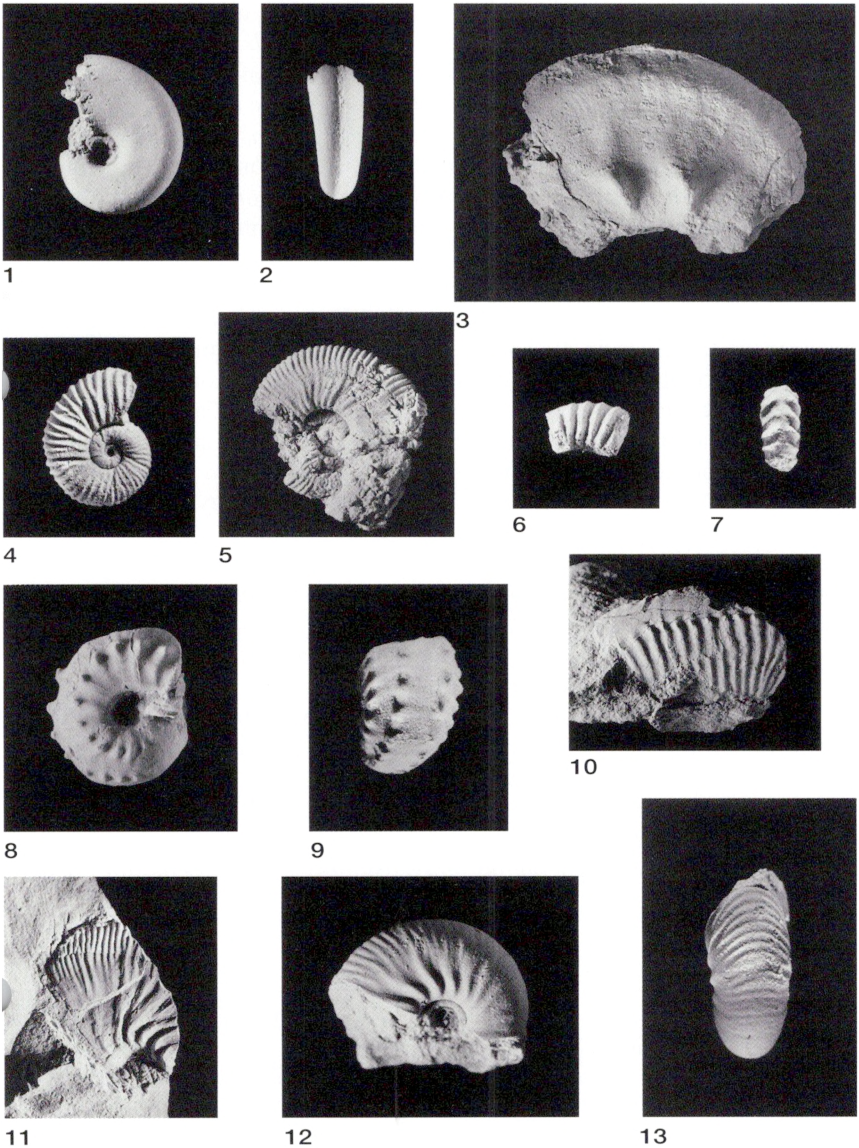


**Fig. 4** (Legend see p. 248)

Saget, etc. Upper Valanginian dark marls yielded an assemblage of *Saynoceras verrucosum* (d'Orbigny), *Valanginites wilfridi* (Karakasch), *V.* ex gr. *nucleus* (Roemer), *Prodichotomites* ex gr. *complanatus* (Koenen), *Neocomites neocomiensis* (d'Orbigny), *N. teschenensis* (Uhlig), *Criosarasinella* cf. *furcillata* Thieuloy, *Bochianites neocomiensis* (d'Orbigny) (Fig. 3, 4). Both the associations mentioned here are accompanied by abundant phylloceratids, lytoceratids and *Neolissoceras grasianum* (d'Orbigny) of little stratigraphical value. Scarcely deformed ammonites (*Criosarasinella* cf. *furcillata* Thieuloy) sculptural molds (no more pyritized specimens) occur in the higher parts of the black shale sequence.

b) Pelites of the Těšín-Hradiště Formation deposited in the "Godula sequence" of the Silesian Basin contain pelosiderite nodules, exploited for iron production during the last century. The concretions contain Valanginian ammonites, which were studied by Uhlig (1883, 1902), and were later revised with additional specimens by Vašíček (1975). The early Valanginian association consists of *Kilianella* ex gr. *roubaudiana* (d'Orbigny), *K. clavicostata* Nikolov, *Fuhriella michaelis* (Uhlig), *Platylenticeras* cf. *heteropleurum* (Neumayr & Uhlig), *Pl. pseudograsianum* (Uhlig), *Busnardoites campylotoxus* (Uhlig), *Neolissoceras salinarium* (Uhlig). In contrast, *Neocomites neocomiensis* (d'Orbigny), *N. teschenensis* (Uhlig), *T. callidiscus* Thieuloy, *T. paraplesius* (Uhlig), *T. scioptychus* (Uhlig) and the first representatives of *N. neocomiensiformis* (Uhlig), are frequent in the late Valanginian ammonite assemblage.

c) No Valanginian ammonite shells have yet been found in the Magura Basin. Calciturbidite intercalations in calcareous flysch deposits yielded an association of early Valanginian aptychi.

d) Lower Valanginian deposits (marly limestones) of the PKB contain no ammonites. The oldest ammonites belong to the Late Valanginian *Saynoceras verrucosum* Zone: *Neocomites platycostatus* (Sayn), *Bochianites neoco-*

**Fig. 5.** Late Valanginian ammonites of the Pieniny Klippen Belt (Outer Carpathians) and of the Manín Unit (Central Carpathians).
**1**: *Criohimantoceras* sp.; Late Valanginian, Revišné locality, spec. Rev-96/8; × 0.7. **2**: *Himantoceras trinodosum* Thieuloy; Late Valanginian, Horné Srnie, "Na Dlhej" quarry, spec. Srn-35/2; × 0.7. **3**: *Criosarasinella furcillata* Thieuloy; Late Valanginian, Butkov quarry (Manín Unit), spec. BK-13; × 0.7. **4**: *Oosterella* ex gr. *gaudryi* (Nickles); Late Valanginian, Horné Srnie, "Na dlhej" quarry, spec. Srn-35/5; × 0.7. **5**: *Valanginites nucleus* (Roemer); Late Valanginian, Revišné locality, spec. Rev-96/3; × 1.4. **6**: *Neocomites praediscus* Reboulet; Late Valanginian, Revišné locality, spec. Rev-96/2; × 1.4. **7**: *Phylloceras (Hypophylloceras) thetys* (d'Orbigny); Late Valanginian, Revišné locality, spec. Rev-96/7; × 0.7.

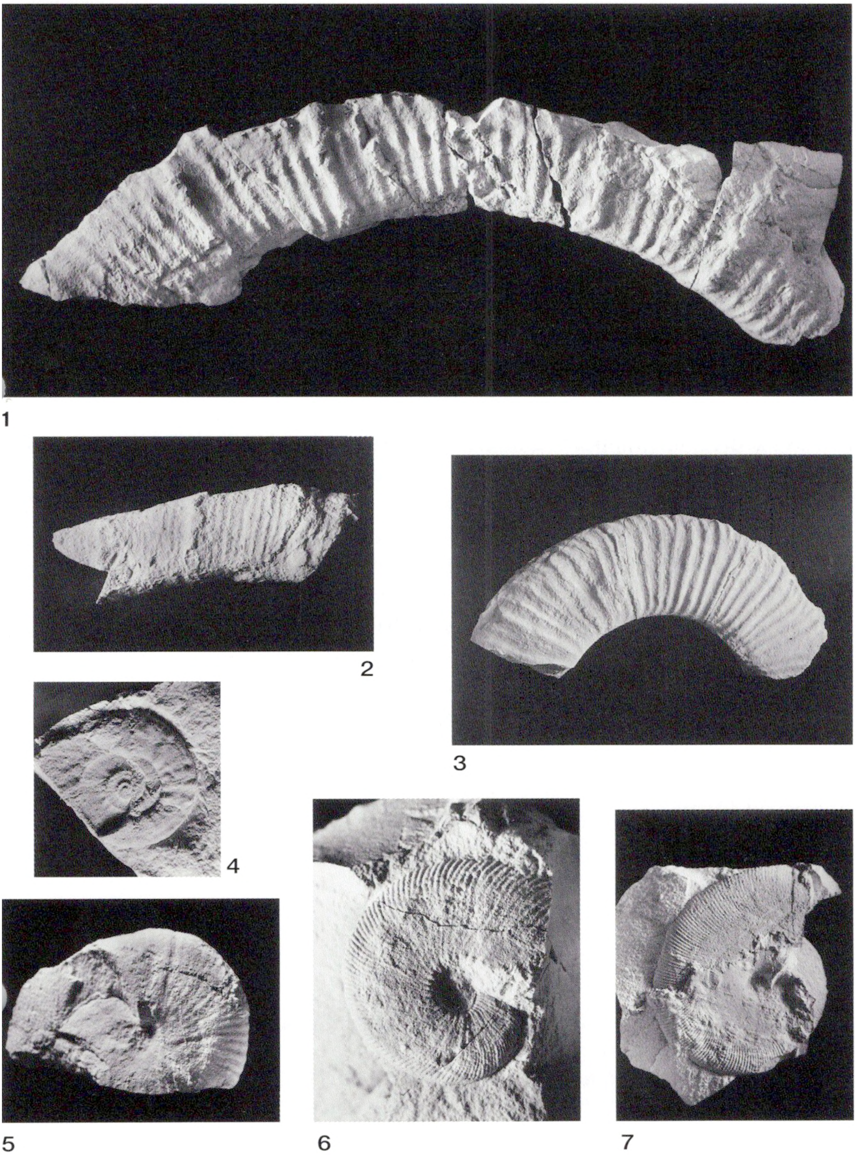


**Fig. 5** (Legend see p. 250)

*miensis* (d'Orbigny), *Protetragonites quadrisulcatus* (d'Orbigny) and *Olcostephanus* sp. (Rochovica locality, Vašíček et al. 1992). Cherty limestones belonging to the *Himantoceras trinodosum* Zone (Fodorka near Horné Srnie, Revišné, Podbranč localities) contain *Neolissoceras grasianum, Olcostephanus* cf. *detonii* (Rodighiero), *Valanginites nucleus* (Roemer), *Bochianites neocomiensis* (d'Orbigny), *B. oosteri, Himantoceras trinodosum* Thieuloy, *Criohimantoceras* sp., *Oosterella* ex gr. *gaudryi* (Nickles), *Jeanthieuloyites* cf. *quinquestriatus* (Besaire), *Neocomites teschenensis* (Uhlig), *N. platycostatus* Sayn, *N. praediscus* Reboulet, and *Olcostephanus* sp. (Fig. 3, 5, 6).

e) Lower Valanginian deposits of the Manín Unit, forming the peripheral part of the Fatric Basin in the Alpine-Carpathian microcontinent contain *Kilianella retrocostata* Sayn, *K. clavicostata* Nikolov, *Neolissoceras salinarium* (Uhlig), *N. grasianum* (d'Orbigny), *Busnardoites campylotoxus* (Uhlig), etc. The upper Valanginian part of this basinal infilling yielded *Neocomites teschenensis* (Uhlig), *N. beaumugnensis* Sayn, *Teschenites subflucticulus* Reboulet, *Himantoceras trinodosum* Thieuloy, *Olcostephanus nicklesi* Wiedmann & Diene, *Bochianites neocomiensis* (d'Orbigny), *Criosarasinella furcillata* Thieuloy, *Cr. heterocostata* (Mandov), (Fig. 3).

f) The central part of the Fatric Basin infilling, forming now a huge body of the Križna Nappe, was inhabited by a less diversified ammonite fauna. The early Valanginian association consists of *Neolissoceras* cf. *salinarium* (Uhlig) and *Sarasinella biformis* (Sayn). The late Valanginian one comprises *Paquiericeras (J.)* cf. *undulatum* Thieuloy, *Juddiceras* cf. *curvicosta* (Koenen), *Criosarasinella* ex gr. *mandovi* Thieuloy and a few other poorly preserved forms.

**Fig. 6.** Late Valanginian and Early Hauterivian ammonites of the Pieniny Klippen Belt (Outer Carpathians).
**1**: *Olcostephanus* cf. *detonii* (Rodighiero); Late Valanginian, Podbranč quarry, 3th level, spec. Pdbr-III/63-64/4; × 1. **2**: *Teschenites flucticulus* Thieuloy (M); Early Hauterivian, Podbiel locality, spec. Pdl-2/1; × 0.7. **3**: *Teschenites flucticulus* Thieuloy (m); Early Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-Ib/11; × 0.7. **4**: *Teschenites* sp.; Usual mode of preservation in the PKB. Early Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-Ib/1; × 1.4. **5**: *Teschenites* cf. *castellanensiformis* Reboulet, Atrops & Autran; Early Hauterivian (?), Podbranč quarry, 1st level, spec. Pdbr-I/1; × 0.7. **6**: *Spitidiscus* cf. *rotula* (Rowerby); Early Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-Ib/12; × 0.7.

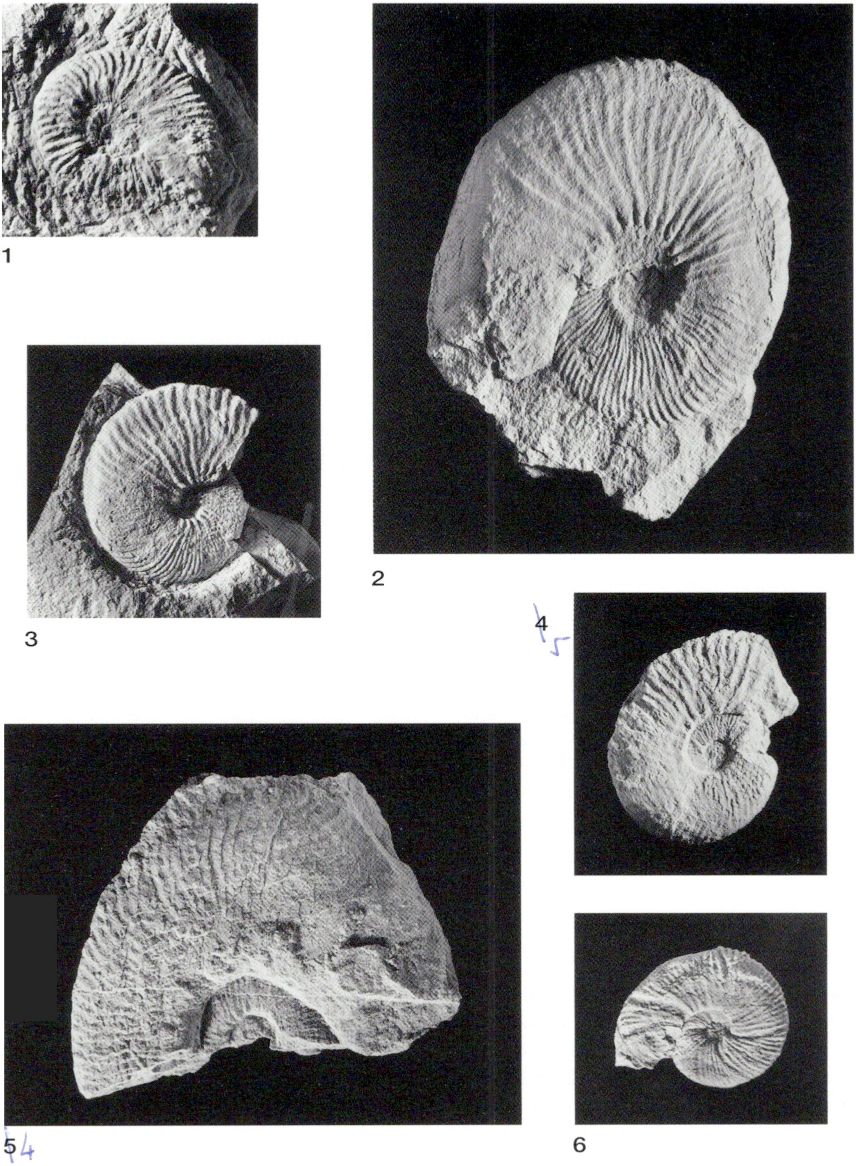


**Fig. 6** (Legend see p. 252)

## Hauterivian

Hauterivian ammonite associations were relativelly abundant and diversified. Studies include ANDRUSOV & SCHEIBNER 1960, ERISTAVI 1961, ADAMIKOVÁ et al. 1983, VAŠÍČEK & MICHALÍK 1986, 1988, MICHALÍK et al. 1995.

a) The early Hauterivian association of the Baška Subunit consists of poorly preserved *Acanthodiscus* sp., *Breistrofferella* sp. and *Endemoceras* cf. *amblygonium* (NEUMAYR & UHLIG).

b) At the same time, *Lytoceras subfimbriatum* (D'ORBIGNY), *Neolissoceras grasianum* (D'ORBIGNY), ?*Spitidiscus* ex gr. *incertus* (D'ORBIGNY) occurred in the Godula Basin (UHLIG 1902). This late Hauterivian association was even more diversified, consisting of *Crioceratites* ex gr. *duvali* (LEVEILLE), *Cr. majoricensis* (NOLAN), *Plesiospitidiscus* sp., *Anahamulina* sp.

c) More diversified ammonite associations inhabited basinal depressions along the border of the European shelf. The infillings of these basins form the present PKB. The early Hauterivian associations are characterized by *Teschenites flucticulus* THIEULOY, *T.* cf. *castellanensiformis* REBOULET, ATROPS & AUTRAN, *Spitidiscus* cf. *rotula* (SOWERBY), *Abrytusites thieuloyi* VAŠÍČEK & MICHALÍK, *Crioceratites loryi* SARKAR, *Cr. nolani* (KILIAN), *Bochianites oosteri* SARASIN & SCHOENDELMAYER, *Olcostephanus (J.) jeannoti* (D'ORBIGNY), etc. By contrast, late Hauterivian associations are dominated by *Subsaynella sayni* (PAQUIER), *Crioceratites* ex gr. *duvali* (LEVEILLE), *Ptychoceras meyrati* OOSTER, *Crioceratites binelli* sensu THOMEL, *Plesiospitidiscus* sp., *Pseudothurmannia* sp. (Fig. 3, 6, 7).

d) The region of the Alpine-Carpathian plate was characterised by a pure Mediterranean fauna. Early Hauterivian associations of the Manín Unit are composed of *Neocomites* ex gr. *neocomiensiformis* (UHLIG), *Eleniceras* ex gr. *tchechitevi* BRESKOVSKI, *Crioceratites nolani* (KILIAN), *Cr. loryi* SARKAR, *Abrytusites thieuloyi* VAŠÍČEK & MICHALÍK, *Jeanthieuloyites nodosus*

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**Fig. 7.** Hauterivian ammonites of the Pieniny Klippen Belt (Outer Carpathians) and of the Križna Nappe (Central Carpathians).

**1**: *Crioceratites nolani* (KILIAN); Early Hauterivian, Podbranč quarry, 2nd level, spec. Pdbr-B1/10; ×0.7. **2**: *Abrytusites thieuloyi* VAŠÍČEK & MICHALÍK; Early Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-Ia/1; ×0.7. **3**: *Paraspiticeras* sp.; Latest Hauterivian, Laz quarry on the Polomec hill (near Lietavská Lučka), spec. LL-95-Laz/12/1; ×0.7. **4**: *Subsaynella sayni* (PAQUIER); Late Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-I/5; ×2.1. **5**: *Crioceratites binelli* sensu Thomel, non Astier; Late Hauterivian, Podbranč quarry, 1st level, spec. Pdbr-Ie/1; ×0.7.

Photos: K. Mezihoráková, University of Ostrava. All figured specimens were coated with ammonium chloride before photographing.

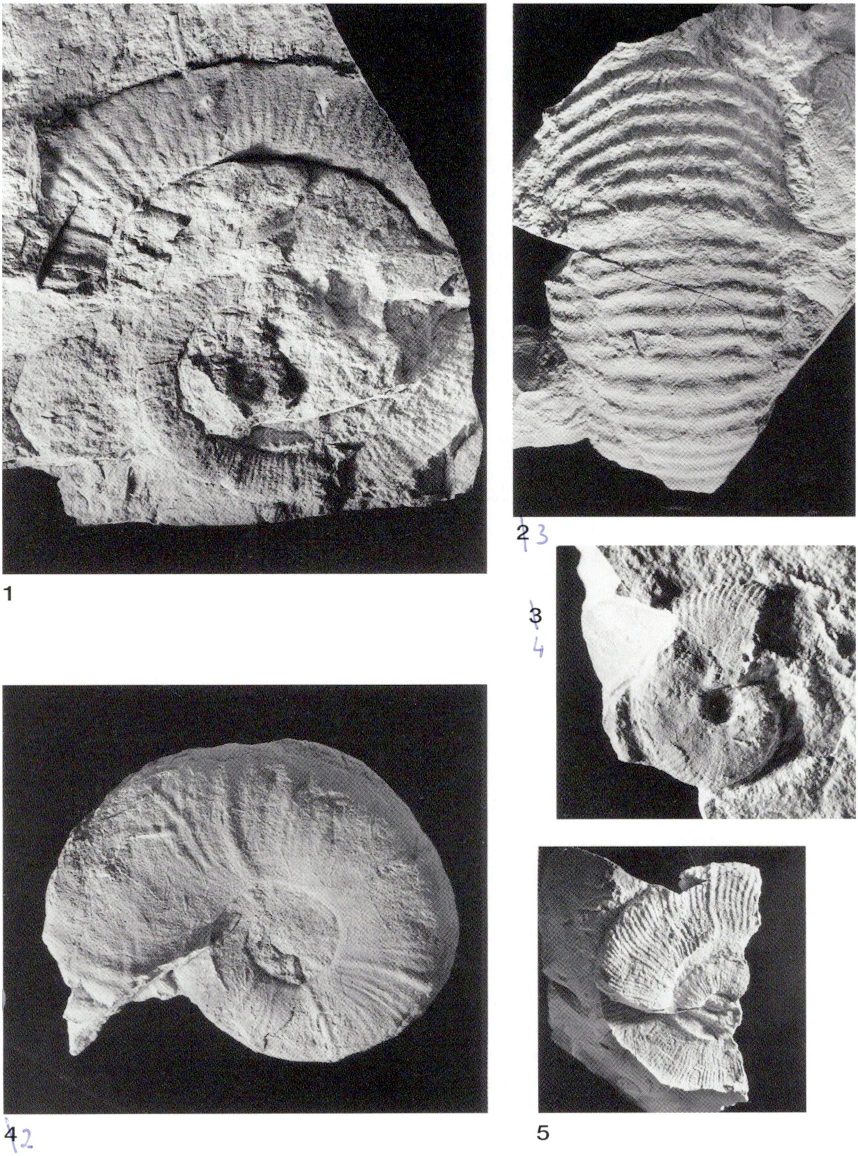


**Fig. 7** (Legend see page 254)

(MANDOV), *Spitidiscus cankovi* VAŠÍČEK & MICHALÍK, *Bochianites oosteri* SARASIN & SCHOENDELMAYER. The late Hauterivian ammonite fauna was also dominated by nektobenthic species: *Crioceratites duvali* (LEVEILLE), *Plesiospitidiscus ligatus* (D'ORBIGNY), *Spitidiscus fasciger* THIEULOY, *Ptychoceras meyrati* OOSTER (Fig. 3).
e) The early Hauterivian fauna from the Zliechov Basin is characterised by *Spitidiscus* cf. *rotula* (SOWERBY), *Crioceratites nolani* (KILIAN), *Olcostephanus hispanicus* (MALLADA), *Bochianites oosteri* SARASIN & SCHOENDELMAYER. Ammonite associations reached maximum of diversity in the Late Hauterivian, including *Subsaynella sayni* (PAQUIER), *Ptychoceras meyrati* OOSTER, *Plesiospitidiscus ligatus* (D'ORBIGNY), *Acrioceras pulcherrimum* (D'ORBIGNY), *Acr. mulsanti* (ASTIER), *Crioceratites matsumotoi* SARKAR, *Pseudothurmannia balearis* (NOLAN), *Ps. shankariae* SARKAR, *Crioceratites majoricensis* (NOLAN), *Ps. mortilleti* (PICTET & LORIOL), *Ps. angulicostata* (D'ORBIGNY), *Cr.* ex gr. *emerici* LEVEILLE, *Cr. binelli* sensu THOMEL, *Anahamulina subcylindrica* (D'ORBIGNY), *Acr. seringei* (ASTIER), *Psilotissotia favrei* (OOSTER), *Pl.* ex gr. *subdifficilis* (KARAKASCH), *Barremites* sp., *Phyllopachyceras infundibulum* (D'ORBIGNY), *Paraspiticeras* sp. (Fig. 3).

## Barremian

The Barremian was characterised by a Mediterranean influx over the whole area and by the closure of the connection with the Boreal Realm. Planktonic ecosystems became reorganized (REHÁKOVÁ 1995b): calpionellid associations were replaced by planktic foraminifera. Huge Urgonian carbonate platforms started to cover submerged topographic rises (MICHALÍK 1994a).
a) During the early Barremian, the ammonite fauna in the marginal Godula Basin was rich and diverse with *Eulytoceras anisoptychum* (UHLIG), *Macroscaphites binodosus* UHLIG, *Acrioceras* cf. *tabarelli* (ASTIER), *Hamulina astieriana* D'ORBIGNY, *Anahamulina hoheneggeri* (UHLIG), *A.* cf. *paxillosa* (UHLIG), *Hamulinites parvulus* (UHLIG), *H. fragile* (UHLIG), *Karsteniceras pumilum* (UHLIG), *K. subtile* (UHLIG), *Eoheteroceras uhligi* (VAŠÍČEK), *Eo. silesiacum* VAŠÍČEK & WIEDMANN, *Manoloviceras saharievae* (MANOLOV), *Paraspiticeras pachycyclum* (UHLIG), *Silesites vulpes* (COQUAND), *Holcodiscus* sp. (Fig. 3).
b) High diversity was also typical for late Barremian associations, including *Costidiscus recticostatus* (D'ORBIGNY), *Eulytoceras phestum* (MATHERON), *Macroscaphites yvani* (PUZOS), *Anahamulina glemmbachensis* IMMEL, *A. rothi* VAŠÍČEK, *A. distans* VAŠÍČEK, *Ptychoceras morloti* OOSTER, *Pt. dittleri* VAŠÍČEK, *Argvethites* sp., *Spinocrioceras amadei* (UHLIG), *Pseudosaynella strettostoma* (UHLIG), *Valdedorsella visulica* (UHLIG), *Matheronites ham-*

*matoptychus* (UHLIG), *Silesites seranonis* (D'ORBIGNY), *Pseudohaploceras liptoviense* (ZEUSCHNER) (VAŠÍČEK 1972, 1973, 1977, 1979, 1981a).
c) With the exception of several specimens of *Barremites* sp., no Barremian ammonites have been reported form PKB so far.
d) The Manín Unit of the Zliechov Basin yielded an impoverished early Barremian ammonite fauna: *Hamulinites* cf. *parvulus* (UHLIG), *Anahamulina* sp., *Psilotissotia favrei* (OOSTER), *Pulchellia compressissima* (D'ORBIGNY), *Valdedorsella uhligi* (HAUG), *Holcodiscus* ex gr. *perezianus* (D'ORBIGNY), *Barremites* sp., etc. The late Barremian associations were even more uniform, being dominated by *Costidiscus recticostatus* (D'ORBIGNY).
e) During the lower Barremian, pelagic type ammonites were abundant in the central part of the Zliechov Basin: *Barremites* sp., *Veveysiceras escheri* (OOSTER), *Hamulinites parvulus* (UHLIG), *Spitidiscus* cf. *hugii* (OOSTER), *Sp. seunesi* (KILIAN), *Hamulina lorioli* UHLIG, *Silesites vulpes* (COQUAND), etc. Late Barremian ammonite associations were dominated by *Costidiscus recticostatus* (D'ORBIGNY), *Silesites seranonis* (D'ORBIGNY), *Eulytoceras phestum* (MATHERON), *Macroscaphites yvani* (PUZOS), *Anahamulina* cf. *glemmbachensis* IMMEL (Fig. 3).

## Aptian

a) The early Aptian ammonite fauna from shaly infillings of the Godula Basin contains *Costidiscus microcostatus* (Sim., Bac. & Sorokin), *Procheloniceras albrechtiaustriae* (UHLIG), *P. pachystephanum* (UHLIG), ?*Prodeshayesites* sp., *Cheloniceras* aff. *seminodosum* (SINZOW), *Acrioceras karsteni* (UHLIG). In the upper Aptian the following taxa are recorded (VAŠÍČEK 1981b): *Acanthohoplites nolani exiquecostatus* EGOIAN, *Tetragonites duvalianus* (D'ORBIGNY), *Nodosohoplites moravicus* VAŠÍČEK, *Acanthohoplites* ex gr. *bigoureti* (SEUNES) (Fig. 3).
b) No Aptian ammonites have been found in the PKB, so far.
c) Early Aptian ammonites of the Križna Nappe (formed by the Zliechov basin infilling) are represented by *Costidiscus tenuistriatus* (REPELIN), *Macroscaphites striatisulcatus* (D'ORBIGNY), *Cheloniceras* cf. *cornuelianum* (D'ORBIGNY), *Deshayesites* ex gr. *involutum* SPATH, *Deshayesites* sp. (VAŠÍČEK & RAKÚS 1995). No ammonites were recovered from the late Aptian of this nappe.

## Albian

a) According to the literature (STUR 1860, 1868), early Albian *Leymeriella tardefurcata* (LEYMERIE) and *Douvilleiceras mammillatum* (SCHLOTHEIM) were found in the Pieniny Klippen Belt. Upper Albian deposits characteristically contain (VAŠÍČEK & RAKÚS 1993) *Kossmatella schindewolfi* WIEDMANN & DIENI, *Hamites (Metahamites) passendorferi* MARCINOWSKI &

WIEDMANN, *Hamites compresus* SOWERBY, *Prohysteroceras (Goodhalites)* cf. *delabechei* SPATH, *Dipoloceras (D.) cristatum* (DELUC), *Hysteroceras orbignyi* (SPATH), *H. carinatum* SPATH.
b) The Tatric Zone of the Central Carpathians (Fig. 2) yielded late Albian ammonite association consisting of *Douvilleiceras mammillatum* (SCHLOTHEIM), *Hoplites dentatus* (SOWERBY), *Dipoloceras cristatum* (DELUC), *Hysteroceras orbignyi* (SPATH), *Mortoniceras inflatum* (SOWERBY), *Tegoceras gladiator* (BAYLE), *Sonneratia dutempleyana* (D'ORBIGNY) and other forms (MARCINOWSKI & WIEDMANN 1985, 1988, 1990; RAKÚS et al. 1994).

## Conclusions

The diversity and abundance of ammonite faunas in the studied Carpathian localities changed both in time and space during the Lower Cretaceous (Fig. 2). These irregularities are partly due to the incompletness of the faunal record. However, the majority of the associations reflect primary differences related to the temporal and spatial variation of paleogeographic environments. The time scale was correlated to the Mediterranean ammonite biostratigraphical scale of HOEDEMAEKER, COMPANY et al. (1993). However, the application of the newer Early Cretaceous zonation proposed by BULOT & THIEULOY (1995) and REBOULET (1996) meets more serious contradictions.

Between the early Valanginian and early Hauterivian, rare Boreal ammonites periodically occurred in associations dominated by Mediterranean forms in the most external Silesian Unit (early Valanginian *Platylenticeras,* early late Valanginian *Prodichotomites,* earliest Hauterivian *Endemoceras*). The Godula Basin was periodically connected to the Boreal Lower Saxony Basin through the Danian-Polish Trough (MAREK & RACZYNSKA 1979, MAREK 1989). Index Boreal ammonites are missing in the upper Hauterivian-to mid Albian sedimentary infilling of the Danian-Polish Trough (the Barremian part is represented by a sedimentary gap). According to MAREK (1989), an important transgression happened during the early-middle Albian boundary interval.

The occurrence of Boreal forms in the more internal zones is rather exceptional. No equivalent of the early Valanginian *Platylenticeras* have been found there. In one locality of the PKB (Revišné) a single occurrence of the late Valanginian *Valanginites nucleus* has been recorded, which can be related to the ammonite Saynoceras verrucosum Zone (similarly to findings of Boreal *Prodichotomites*), known in Mediterranean and Boreal Polish and German regions.

No Boreal forms have been found in Central Carpathian ammonite associations, which consist of purely Mediterranean taxa, except for one incomplete fragment of the late Valanginian *Juddiceras.* Ammonite findings become rare in the uppermost Barremian-lowermost Aptian in this area. Late Albian ammonites have only been found in the Pieniny Klippen Belt (Vašíček 1995a).

## References


Adamiková, G., Michalík, J. & Vašíček, Z. (1983): Composition and ecology of the "Pseudothurmannia Fauna", Lower Barremian of the Križna Nappe in Stražovské Vrchy Mts. – Geol. Zborn. Geol. Carpath., **34**: 591-615.

Andrusov, D. & Scheibner, E. (1960): An outline of the present state of knowledge about the geology of the Klippen Belt between Vlára River and town of Tvrdošín. – Geol. Sborn. Slov. Akad. Vied, **11**: 239-279.

Autran, G. (1993): L'évolution de la marge N-E provençale (arc de Castellane) du Valanginien moyen à l'Hauterivien à travers l'analyse biostratigraphique des séries de la région de Peyroules: séries condensées, discontinuités et indices d'une tectonogénèse distensive. Paléobiologie. – Ann. Mus. Hist. nat. Nice, **10**: 240 p.

Bulot, L., Argot, M. & Arnaud, H. (Eds. 1995): Lower Cretaceous cephalopod biostratigraphy of the Western Tethys: recent developments, regional synthesis and outstanding problems. – Géol. Alpine, Mem. h.s., **20**: 420 p.

Bulot, L.H. & Thieuloy, J.-P. (1995): Les biohorizons du Valanginian du Sud-Est de La France: un outil fondamental pour les corrélations au sein de la Tethys occidentales. – Geol. Alpine, Mem. h.s., **20**: 15-41.

Cecca, F. (Ed. 1995): Proceedings of 3rd workshop on Early Cretaceous cephalopods. – Mem. Descr. Carta Geol. Ital., **51**: 218 p.

Eliáš, M., Martinec, P., Reháková, D. & Vašíček, Z. (1996): Geology and Stratigraphy of the Kurovice Limestone and Tlumačov Marl Formation at the Kurovice quarry (Upper Jurassic-Lower Cretaceous, Outer Western Carpathians, Czech Republic). – Bull. Czech Geol. Survey, **71**, 3: 259-275.

Eristavi, M.S. (1961): Some Lower Cretaceous cephalopods from Central Carpathians. – Geol. Prace, Zprávy, **21**: 81-108.

Hoedemaeker, P.J., Company, M. (Eds.) et al. (1993): Ammonite zonation for the Lower Cretaceous of the Mediterranean region; basis for the stratigraphic correlations within IGCP Project 262. – Revista Esp. Paleont., **8**: 117-120.

Hohenegger, L. (1855): Neuere Erfahrungen aus den Nordkarpathen. – Jahrb. k.u. k. geol. Reichsanstalt, **7**: 304-313.

– (1861): Die geognostischen Verhältnisse der Nordkarpathen in Schlesien und den angrenzenden Theilen von Mähren und Galizien als Erläuterung zu der geognostischen Karte der Nordkarpathen. – 50 p.; Gotha.

Houša, V. & Vašíček, Z. (in press): Ammonoidea of Early Cretaceous deposits in the Štramberk Area. – Zem. Plyn Nafta (Hodonín).

Kutek, J. & Wierzbowski, A. (1986): A new account on the Upper Jurassic stratigraphy and ammonites of the Czorsztyn Succession, Pieniny Klippen Belt, Poland. – Acta geol. Polon., **36**: 289-316.

Marcinowski, R. & Wiedmann, J. (1985): The Albian ammonite fauna of Poland and its paleogeographical significance. – Acta geol. Polon., **35**: 199-219.

Marcinowski, R. & Wiedmann, J. (1988): Paleogeographic implications of the Albian ammonite faunas of Poland. – In: Wiedmann, J. & Kullmann, J. (Eds.): Cephalopods – Present and Past: 491-504; Stuttgart (E. Schweizerbart).

– (1990): The Albian ammonites of Poland. – Palaeont. Polon., **50**: 3-94.

Marek, S. (1989): Sedimentäre und Palaeotektonische Entwicklung der epikontinentalen Unterkreide Polens. – In: Wiedmann, J. (Ed.): Cretaceous of Western Tethys. – Proc. 3rd Intern. Cret. Symp. Tübingen 1987: 755-770; Stuttgart (E. Schweizerbart).

Marek, S. & Raczynska, A. (1979): Palaeogeographie der Unterkreide des nordpolnischen Beckens. – In: Wiedmann, J. (Ed.): Aspekte der Kreide Europas. – IUGS ser., **A 6**: 447-462.

Michalík, J. (1990): Paleogeographic changes in the West Carpathian region during Kimmerian tectonic movements. – Acta Geolog. Geogr. Univ. Comen., Geol., **45**: 43-54.

– (1993): Mesozoic tensional basins in the Alpine-Carpathian shelf. – Acta geol. Hung., **36**,4: 395-403.

– (1994a): Lower Cretaceous carbonate platform facies, Western Carpathians. – Palaeogeogr., Palaeoclim., Palaeoecol., **111**: 263-277.

– (1994b): Notes on the paleogeography and paleotectonics of the Western Carpathian area during Mesozoic. – Mitt. Oesterr. Geol. Ges., **86**: 101-110.

– (1995): Lower Cretaceous stratigraphy, facies, life and Tethyan/Boreal influence in Western Carpathians. – Cret. Research, **16**: 299-310.

Michalík, J., Reháková, D., Vašíček, Z. (1995): Early Cretaceous sedimentary changes in West Carpathian area. – Geol. Carpath., **46**,5: 285-296.

Michalík, J., Reháková, D., Hladíková, J. & Lintnerová, O. (1995): Lithological and biological indicators or orbital changes in Tithonian and Lower Cretaceous sequences, Western Carpathians, Slovakia. – Geol. Carpath., **46**,3: 161-174.

Mutterlose, J. (1992): Migration and evolution patterns of floras and faunas in marine Lower Cretaceous sediments of NW Europe. – Palaeogeogr., Palaeoclim., Palaeoecol., **94**: 261-282.

Neumayr, M. (1871): Jurastudien 3: Die Phylloceraten des Doggers und Malm. Der Pieninische Klippenzug. – Jahrb. k. u. k. geol. Reichsanstalt, **3-4**: 21-120.

Patrulius, D. & Avram, E. (1976): Les cephalopodes des couches de Carhaga (Tithonique supérieur-Barrémien inférieur). – Mem. Inst. Geol. Geoph., **24**: 153-201.

Rakús, M., Vašíček, Z. & Pavlarčík, S. (1994): Albian ammonites from the Mokra Diera Cave in the Javorova Valley (Vysoké Tatry Succession, High Tatras). – Miner. Slovaca, **27**: 207-212.

Reboulet, S. (1996): L'évolution des ammonites du Valanginien-Hauterivien inférieur du Bassin Vocontien et de la Plate-Forme Provençale (S-E de la France): relations avec la stratigraphie séquentielle et implications biostratigraphiques. – Doc. Lab. Geol. Lyon, **137**: 371 p.

Reháková, D. (1995a): Upper Jurassic-Lower Cretaceous carbonate microfacies and environmental models for the Western Carpathians and adjacent paleogeographic Units. – Cret. Research, **16**: 283-297.

REHÁKOVÁ, D. (1995b): New data on calpionellid distribution in the Upper Jurassic/ Lower Cretaceous formations (Western Carpathians). – Miner. Slovaca, **27**: 308-318.

REHÁKOVÁ, D. & MICHALÍK, J. (1994): Abundance and distribution of Late Jurassic and Early Cretaceous microplankton in Western Carpathians. – Geobios, **27**,2: 135-156.

REHÁKOVÁ, D., ŠULGAN, F., VAŠÍČEK, Z. & MICHALÍK, J. (1995): Environment, fauna and paleogeographic importance of Berriasian limestones from the Vigantice tectonic slice in the Outer Western Carpathians. – Geol. Carpath., **46**, 1: 53-58.

SPAETH, CH. (Ed.) (1996): New developments in Cretaceous research topics. – Mitt. Geol.-Paläont. Inst. Univ. Hamburg, Proc. 4th Intern. Cret. Symp. 1992 – Jost Wiedmann's Memor. Vol., **77**: 671 p.

UHLIG, V. (1883): Die Cephalopodenfauna der Wernsdorferschichten. – Denkschr. Oesterr. Akad. Wiss., math.-nat. Klasse, **46**: 127-290.

– (1902): Ueber die Cephalopodenfauna der Teschener und Grodischter Schichten. – Denkschr. Oesterr. Akad. Wiss., math.-nat. Klasse, **72**: 1-88.

VAŠÍČEK, Z. (1972): Ammonoidea of the Těšín-Hradiště Formation (Lower Cretaceous) in the Moravskoslezské Beskydy Mts. – Rozpravy Ústř. Úst. Geol., **38**: 103 p.

– (1973): Über einige von V. UHLIG (1883) beschriebene Unterkreide-Ammoniten. – Sborn. geol. Věd, Paleont., **15**: 49-73.

– (1975): Zur Revision der Ammoniten von den Oberen Těšín-Schichten. – Sborn. geol. Věd, Paleont., **17**: 71-107.

– (1977): Hukvaldy – die neue makrofaunistische Lokalität der Schlesischen Einheit (Hauterive). – Čas. Slez. Muz., **A 26**: 129-136.

– (1979): Die Cephalopoden der schlesischen Unterkreide und ihre palaeogeographische Bedeutung. – In: WIEDMANN, J. (Ed.): Aspekte der Kreide Europas. – IUGS Ser., **A 6**: 323-334.

– (1981a): Zwei neue faunistische Fundorte der Unterkreide in der Silesischen Einheit und Zusammenfassung der Revision der von V. UHLIG (1883) beschriebenen Ammoniten. – Sborn. věd. Prací Vys. Šk. bán., horn.-geol., **25**: 119-134.

– (1981b): Die Clansay-Ammoniten der höchsten Hradiště-Schichten (Silesische Einheit, Tschechoslowakei). – Sborn. věd. Prací Vys. Šk. bán., horn.-geol., **25**: 193-204.

– (1990): Unterkreide-Ammoniten aus neu abgeteuften Schachten im Gebiet von Frenštát-Trojanovice (Äußere Karpaten, Silesische Einheit, ČSFR). – Čas. Mor. Muz., Vědy přír., **75**: 95-116.

– (1995a): Aptian and Albian ammonites in the Western Carpathians (the Czech and Slovak Republics). – Mem. Descr. Carta Geol. Ital., **51**: 167-171.

– (1995b): Lower Cretaceous ammonite biostratigraphy in the Western Carpathians (the Czech and Slovak Republics). – Geol. Alpine, Mem., h.s., **20**: 169-189.

VAŠÍČEK, Z. & MICHALÍK, J. (1986): The Lower Cretaceous ammonites of the Manín Unit (Mt Butkov, Western Carpathians). – Geol. Zborn. Geol. Carpath., **37**: 449-481.

VAŠÍČEK, Z. & MICHALÍK, J. (1988): Some heteromorphic ammonites from Polomec (Hauterivian-Barremian, Central Western Carpathians, Czechoslovakia). – Geol. Zborn. Geol. Carpath., **39**: 655-674.

VAŠÍČEK, Z., MICHALÍK, J. & REHÁKOVÁ, D. (1994): Early Cretaceous stratigraphy, palaeogeography and life in Western Carpathians. – Beringeria, **10**: 169 p.

VAŠÍČEK, Z. & RAKÚS, M. (1993): Upper Albian Ammonoidea from the Povážský Chlmec locality near Žilina (Klape Unit, Klippen Zone, Slovakia). – Západ. Karpaty, Paleont., **17**: 41-56.

– (1995): Lower Aptian Ammonites from the Medziholie locality (the Malá Fatra Mountains, Slovakia). – Mem. Descr. Carta Geol. Italia, **51**: 173-183.

VAŠÍČEK, Z., REHÁKOVÁ, D., MICHALÍK, J., PETERČÁKOVÁ, M. & HALÁSOVÁ, E. (1992): Ammonites aptychi, nanno- and microplankton from the Lower Cretaceous Pieniny Formation in the "Kysuca Gate" near Žilina (Western Carpathian Klippen Belt, Kysuca Unit). – Západ. Karpaty, Paleont., **16**: 43-57.

VAŠÍČEK, Z. & WIEDMANN, J. (1994): The Leptoceratoidinae: small heteromorph ammonites from the Barremian. – Palaeontology, **37**: 203-239.

WIERZBOWSKI, A. (1994): Late Middle Jurassic to earliest Cretaceous stratigraphy and microfacies of the Czorsztyn Succesion in the Spisz area, Pieniny Klippen Belt, Poland. – Acta geol. Polon., **44**: 223-249.

WIERZBOWSKI, A. & REMANE, J. (1992): The ammonite and calpionellid stratigraphy of the Berriasian and lowermost Valanginian in the Pieniny Klippen Belt (Carpathians, Poland). – Eclogae geol. Helv., **85**: 871-891.

ZEUSCHNER, L. (1856): Geognostische Beschreibung des Liaskalkes in der Fatra und in den angrenzenden Gebieten. – Sonderber. Akad. Wiss., **19**: 136-182.

ZITTEL, K. A. (1868): Die Cephalopoden der Stramberger Schichten. – Palaeont. Mitt. Mus. Bayer. Staats., **2**: 118 p.

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