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AMMONITE STRATIGRAPHY OF THE PRE-ALBIAN LOWER CRETACEOUS FORMATIONS OF THE WESTERN CARPATHIANS (CZECH AND SLOVAK REPUBLICS)

ZDENĚK VAŠÍČEK

Institute of Geological Engineering, VŠB-Technical University of Ostrava, tř. 17 listopadu, 708 33 Ostrava-Poruba, Czech Republic

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Abstract: Several decades have already passed since the period of the basic geological-stratigraphic research on the Lower Cretaceous formations of the Western Carpathians carried out by Dimitrij Andrusov. The first part of this work looks at the existing state of internationally recognized ammonite stratigraphy on the level of ammonite zones and horizons (subzones) and the placing of boundaries between stratigraphic stages and substages. The second part attempts to summarize recent findings from the area of ammonite stratigraphy of the ammonite-bearing Lower Cretaceous formations in the western part of the Outer and Central Carpathians, occurring on the Czech and Slovak territories. The summary is based above all on the author's own collections in the field, his systematic study and revision of the older material and also on the results of cooperation with other specialists.

Key words: Lower Cretaceous, Outer and Central Western Carpathians, ammonite stratigraphy.

Introduction

Up to about the 1960s, the stratigraphy of the Lower Cretaceous formations of the Western Carpathians, supported mainly by ammonites, was closely connected with the name of the outstanding geologist Dimitrij Andrusov, the centenary of whose birth we are celebrating this year. A review of the state of knowledge of the time about the stratigraphy and geology of the Western Carpathians culminates especially with his monograph "Geology of the Czechoslovak Carpathians", the second part of which (1959) is devoted to the Mesozoic. Here the Lower Cretaceous deposits are divided into the below mentioned ammonite belts, essentially corresponding to ammonite zones. However, as Table 1 shows, some his ammonite belts are placed one formation higher (*Neocomites neocomiensis* to the Hauterivian, *Pseudothurmannites angulicostatus* to the Barremian and *Acanthoplites bigoureti* to the Albian) in comparison with the present version.

Compared to the period of Andrusov's basic research on the biostratigraphy of the Lower Cretaceous, in recent decades, on the most varied international levels, beginning with the level of IUGS, a lot of attention has been devoted to the composition of the Mediterranean faunistic province, including the ammonite stratigraphy of the Lower Cretaceous. The projects of the IGCP no. 262 (Tethyan Cretaceous Correlation) and no. 362 (Stratigraphic correlation and definition of geoevents in Cretaceous sedimentary sequences of the Tethyan and Boreal realm) were or are being carried out in the framework of the IUGS. The Fourth Cretaceous Symposium was held in Hamburg in 1992, the Second International Symposium on the Boundaries of the Cretaceous Stages in Brussels in 1995, the Jost Wiedmann Symposium in Tuebingen in 1996 and the Fifth Cretaceous Symposium at Freiberg in 1996, as well as were organized workshops of the cephalopod working group for the pre-Albian stages (Digne 1992; Mula 1993; Piobbico 1994). On the level of the Czech and Slovak Republics, grant projects on the Cretaceous, connected with the above mentioned international programmes (e.g. VEGA Grant no. 1081, GAČR no. 205/96/0753) continued or are continuing in close mutual cooperation.

The results of these international conferences were published in many important collected papers. For the area of ammonite stratigraphy in recent years, it is especially necessary to mention a collection of works in the volume "Lower Cretaceous Cephalopod Biostratigraphy of the Western Tethys" (ed. by Bulot, Argot & Arnaud 1995), the "Proceedings of the 3rd Workshop on Early Cretaceous Cephalopods" (ed. by Cecca 1995), "Proceedings of the 4th International Cretaceous Symposium Hamburg 1992" (ed. by Spaeth 1996), "Proceedings of the 2nd International Symposium on Cretaceous Stage Boundaries Brussels 1995" (ed. by Rawson et al. 1996). Apart from these, some important monographs on ammonites were published (Delanoy 1992; Autran 1993; Reboulet 1995 and others), which together with further contributions are constantly improving the accuracy of our knowledge of the systematic position and especially the sequence, range and stratigraphic significance of ammonite species.

Lower Cretaceous ammonite zones

The proposals of the working group for Lower Cretaceous cephalopods published by Hoedemaeker & Bulot (1990) and Hoedemaeker, Company et al. (1993) are the basis for the present division of the Lower Cretaceous of the Mediterranean region on the level of ammonite zones. In recent times, ammonite zones have been proposed for some stratigraphic

Table 1: Division of the Carpathian Lower Cretaceous into ammonite zones according to Andrusov (1959).

Albian	Stoliczkaia dispar Pervinquieria inflata Hysteroceras varicosum Hoplites dentatus Leymeriella tardefurcata Acanthoplites bigoureti
Aptian	Cheloniceras subnodosocostatum Deshayesites deshayesi
Barremian	Macroscaphites yvani Nicklesia pulchella Pseudothurmannites angulicostatus Barremites difficilis
Hauterivian	Crioceratites duvali Acanthodiscus radiatus Neocomites neocomiensis
Valanginian	Saynoceras verrucosum Kilianella roubaudiana
Berriasian	Thurmannites boissieri

stages, and made more precise with ammonite horizons (distinguished especially in the Valanginian and Hauterivian in the area of the Vocontian Trough, see Bulot et al. 1992; Atrops & Reboulet 1993, 1995; Bulot & Thieuloy 1995 and others). A still not entirely unambiguous correlation of the Mediterranean zones with the Boreal zones has also appeared (e.g. Rawson 1995; Mutterlose et al. 1996).

The latest, although not entirely final state of ammonite zoning is summarized by the results of the already mentioned Second International Symposium on Cretaceous Stage Boundaries (Rawson et al. 1996). The boundaries of the majority of Lower Cretaceous stages were accepted at the symposium in the traditional way, on the basis of ammonite zones, which are given in the above mentioned publication, with some exceptions (e.g. the Valanginian and Albian) for every stage.

The boundary between the Berriasian and Valanginian is one of exceptions to the identification of boundaries. Here the definition is not done traditionally on the basis of ammonites, but by something higher than it has been usual in recent years, that is according to the first occurrence of *Calpionellites darderi* (the base of the Remane's Calpionellid Zone E). The base of zone E roughly coincides with the base of ammonite Pertransiens Zone. However, as Bulot et al. (1996) say, this proposal is not regarded as a definitive solution.

Tables 2 and 3 contain the Mediterranean ammonite zones, according to Hoedemaeker, Company et al. (1993), for the Lower Cretaceous stratigraphic stages, which are best documented by ammonites in the Western Carpathians on the territories of the Czech and Slovak Republics. Table 2 is extended to include ammonite horizons defined in France recently. The uppermost two horizons in the Angulicostata Zone are defined by Hoedemaeker (1995).

The ammonite-bearing formations in the Western Carpathians

Mesozoic sedimentation in the Western Carpathians occurred in two basic mega-units, which correspond to the Outer and Central Carpathians. The Outer Carpathian sedimentation basins were situated in the area of the Paleo-European Shelf in the foreland of the Bohemian Massif, the Central Carpathian on the Alpine-Carpathian microcontinent (Michalík 1993, 1994; Vašíček et al. 1994). They were separated from each other by the oceanic crust of the Penninic, designated the Vahic Unit in the Carpathians. The later phases of the Alpine folding in the Upper Cretaceous (in the Central Carpathians) and in the Tertiary in the Outer or Flysch Carpathians led to the complex nappe structure of both these units, which became part of the extensive Alpine mountain belt. The Lower Cretaceous sediments in the Carpathian nappes are usually only incompletely preserved.

The richest occurrences of ammonites in the Outer Carpathians are associated with Lower Cretaceous, mostly dark grey coloured, pelitic deposits of the Silesian Nappe from the area of the Baška Ridge and the Godula Basin and also with some parts of the Pieniny Klippen Belt. In the Central Carpathians, the light marly limestones of the Manín Nappe in the Tatric Zone and also some parts of the Krížna Nappe deposited in the Zliechov Basin in the Fatric (Vašíček & Michalík 1996) can be ranked among the richest ammonite-bearing deposits.

The Outer Carpathians

The Silesian Nappe — Baška Development

The richest occurrences of ammonites from the elevation of Baška development of the Silesian Unit are attached to the area of Štramberk in connection with outcrops of the reefogenic Štramberk limestone (Tithonian–Lower Berriasian). These limestones in a complicated tectonic position at the base of the nappe are accompanied by layers, shreds and clasts of greenish and red Lower Cretaceous limestones and dark grey shaly pelites (Houša & Vašíček 1996). In the Lower Cretaceous limestones, ammonites are mostly fragmentarily preserved as sculptural moulds and stone cores, usually with traces of reworking. Ammonites in the pelites are preserved as juvenile pyrite steikerns or as strongly deformed sculptured moulds of adult shells. As shown by the manner of preservation and the composition of associations in individual faunistic horizons, the Lower Cretaceous ammonites are mostly redeposited. Findings of them are accompanied by numerous benthic organisms, especially bivalves, gastropods, brachiopods and echinoderms. The stratigraphic position and sequence of ammonites in the stratal sequence can be determined only approximately, and mainly on the basis of data in the literature.

In a collection of more than 300 ammonites, almost 30 species were successfully determined and many of other specimens were determined only on the genus level, giving a total of 27 genera or subgenera. A detailed systematic study of them is being prepared for publication at present (Houša & Vašíček in prep.). The list of species is as follows: *Phylloce-*

Table 2: Detailed division of the Valanginian and Hauterivian of France into ammonite horizons, and their correlation with boreal horizons. Abbreviations of generic names in the table: B — *Breistrofferella,* Ba — *Baronnites,* Bu — *Busnardoites,* C — *Crioceratites,* Cr —*Criosarasinella,* Cu — *Cruasiceras,* D — *Dicostella,* Di — *Dichotomites,* El — *Eleniceras,* En — *Endemoceras,* K — *Kilianella,* Ka —*Karakaschiceras,* L — *Lyticoceras,* N — *Neocomites,* Ol — *Olcostephanus,* Pi — *Picteticeras,* Pl — *Platylenticeras,* Po — *Polyptychites,* Pr — *Prodichotomites,* Ps — *Pseudothurmannia,* S — *Simbirskites,* Sa — *Saynoceras,* Su — *Subsaynella,* T — *Teschenites,* Ti — *Tirnovella,* V — *Varlheidites.*

Mutterlose 1996, Rawson 1995	Bulot & Thieuloy 1995		Atrops & Reboulet 1995, Reboulet 1995	Hoedemaeker, Company et al. 1993	
S. discofalcatus	Ps. catulloi Ps. ohmi			ANGULICOSTATA	U. Hauterivian
S. gottschei				BALEARIS	
S. staffi	Su. mimica	LIGATUS		LIGATUS	
S. inversum	Cu. cruasense	SAYNI		SAYNI	
En. regale	Ol. variegatus	NODOSOPLICATUM	L. bargemensis L. nodosoplicatum	NODOSOPLICATUM	L. Hauteriv.
En. noricum	Ol. jeannoti C. loryi	LORYI	Ol. jeannoti C. loryi	LORYI	
En. amblygonium El. paucinodum	L. buxtorfi B. castellanensis	RADIATUS		RADIATUS	
D. tuberculata	T. callidiscus	CALLIDISCUS		CALLIDISCUS	Upper Valanginian
Di. bidichotomoides Di. triptychoides	Cr. furcillata Ol. nicklesi	TRINODOSUM	Cr. subheterocostata Cr. furcillata Ka. companyi Ol. nicklesi	TRINODOSUM	
Di. crassus Pr. polytomus Pr. holwedensis	V. peregrinus Ka. pronecostatum Sa. verrucosum	VERRUCOSUM	V. peregrinus Ka. pronecostatum N. neocomiensis Sa. verrucosum	VERRUCOSUM	
		INOSTRANZEWI	N. platycostatus	CAMPYLOTOXUS	Lower Valanginian
Po. hapkei Po. clarkei Po. multicostatus Po. pavlovi Pl. involutum Pl. heteropleurum Pl. robustum	Bu. campylotoxus Bu. subcampylotoxus Ba. hirsutus	STEPHANOPHORUS	Ka. biassalensis Sa. fuhri Ka. quadristrangulatum Ba. hirsutus		
		PERTRANSIENS	E	PERTRANSIENS	
	K. thieuloyi Ti. otopeta	OTOPETA	Ti. otopeta	OTOPETA	
		ALPILLENSIS	Ti. alpillensis Pi. picteti D_3 D_2	BOISSIERI	Berrias.p.p.

ras (Ph.) serum Oppel, *Ph. (Hypophylloceras)* ex gr. *thetys* (d'Orbigny), *Ptychophylloceras semisulcatum* (d'Orbigny), *Sowerbyceras (Holcophylloceras) calypso* (d'Orbigny), *Lytoceras* cf. *subfimbriatum* (d'Orbigny), *Protetragonites quadrisulcatus* (d'Orbigny), *Neolissoceras grasianum* (d'Orbigny), *N. salinarium* (Uhlig), *Fauriella* cf. *boissieri* (Pictet), *Thurmanniceras thurmanni* (Pictet & Campiche), *Th.* cf. *pertransiens* (Sayn), *Kilianella* ex gr. *roubaudiana* (d'Orbigny), *K.* cf. *clavicostata* Nikolov, *Neocomites neocomiensis* (d'Orbigny), *N. teschenensis* (Uhlig), *Criosarasinella* cf. *furcillata* Thieuloy, *Karakaschiceras* ex gr. *quadristrangulatum* (Sayn), *Olcostephanus (O.)* ex gr. *stephanophorus* (Matheron), *Platylenticeras* ex gr. *marcousianum* (d'Orbigny), *Pl. cardioceroides* (Sayn), *Valanginites wilfridi* (Karakasch), *V.* cf. *bachelardi* (Sayn), *Saynoceras verrucosum* (d'Orbigny), *Prodichotomites* ex gr. *complanatus* (Koenen), *Protancyloceras* cf. *punicum* Arnould-Saget, *Bochianites neocomiensis* (d'Orbigny) and *B. oosteri* Sarasin & Schoendelmayer.

Some fragmentary or juvenile shells, found most frequently in one to two specimens, have successfully been assigned only to the genus level (usually as sp. juv.). In spite of this they significantly complete the picture of the ammonite association: *Partschiceras* Fucini, *Sarasinella* Uhlig, *Neohoploceras* Spath, *?Dicostella* Busnardo, *Breistrofferella* Thieuloy, *Endemoceras* Thiermann and *Acanthodiscus* Uhlig.

The composition of the collection according to assignment to ammonite suborders is as follows: almost 50 % belong to the stratigraphically unimportant suborders Phylloceratina and Lytoceratina, 49 % to the suborder Ammonitina and mere 2.6 % to the heteromorph ammonites of the suborder Ancyloceratina. From the suborder Ammonitina, stratigraphically unimportant haploceratids (47 %) represent by far the most substantial part. Representatives of the genus *Kilianella* (about 20 %) are also abundant, and a little more than 30 % belong to the remaining 16 genera of great stratigraphic importance. The submitted data, as was already said, actually reflects the composition of the whole collection regardless of detailed stratigraphy because in the material the exact stratigraphic position of the finds is not known. In general, it can only be stated that the determined species and genera show a stratigraphic range from the uppermost Berriasian to the lower part of the Early Hauterivian inclusive.

The oldest deposits with ammonites around the boundary between the Berriasian and Valanginian are shown by the fragments of *Fauriella* cf. *boissieri* and *Protancyloceras* cf. *puni-*

Table 3: Ammonite zones of the Barremian to Early Albian according to Hoedemaeker, Company et al. (1993).

Alb.	p. p.	Douvilleiceras mammilatum Leymeriella tardefurcata
Aptian	U.	Hypacanthoplites jacobi Acanthohoplites nolani
	M.	Parahoplites melchioris Epichelon. subnodosocostatum
	Lower	Dufrenoyia furcata Deshayesites deshayesi Deshayesites weissi Deshayesites tuarkyricus
Barremian	Upper	Martelites sarasini Imerites giraudi Hemihoplites feraudianus Heinzia sartousiana Ancyloceras vandenheckii
	Lower	Holcodiscus caillaudianus Subpulchellia nicklesi Spitidiscus hugii

cum. The Early Valanginian is indicated especially by *Thurmanniceras thurmanni* and *Platylenticeras* ex gr. *marcousianum* (or other platylenticeratids) and apparently also the abundant occurrence of *Neolissoceras salinarium*. The Late Valanginian is documented especially by the zonal species *Saynoceras verrucosum*, also by *Prodichotomites* ex gr. *complanatus* and *Criosarasinella* cf. *furcillata*. The basal Hauterivian is shown by single, fragmentary, strongly deformed sculptured moulds, determinable only on the genus level: *Acanthodiscus* sp., *Breistrofferella* sp. and *Endemoceras* sp.

As is apparent from the enumeration of determined genera and species of ammonites, beside a significant dominance of Mediterranean elements, Boreal ammonites exceptionally occur in the collection (only about 3 % of the total number of shells). These indicate a periodic, evidently only short-term penetration of Boreal elements into the Silesian sedimentary area: *Platylenticeras* at the beginning of the Early Valanginian, *Prodichotomites* at the beginning of the Late Valanginian and *Endemoceras* at the beginning of the Hauterivian. So far stratigraphically younger ammonites have not been successfully identified in the Štramberk area.

The Silesian Nappe — Godula Development

Rich finds of ammonites, from the perhaps 1 km thick Lower Cretaceous stratigraphic sequence, come only from the grey to dark grey coloured, mostly pelitic deposits with nodules of ironstones, which are designated as the Těšín-Hradiště Formation in Czech geological literature. Since the deposits of the Těšín-Hradiště Formation are not very resistent to weathering, the continuous sections or natural exposures of a greater extent with a more continuously exposed stratal sequences do not occur. The ammonite finds from the lower part of this formation are associated only with the ironstones nodules. The ammonite findings date back to last century, when the nodules were extracted as iron ore. They were studied by Hohenegger (1861) and Uhlig (1902), with later revision by Vašíček (1975). The species composition of Hohenegger's collection, perhaps originally including almost fifty specimens, is as follows: *Sowerbyceras (Holcophylloceras) calypso, Ptychophylloceras semisulcatum semisulcatum, Pt. s. kiliani* (Sayn), *Lytoceras triboleti* Uhlig, *Proteteragonites quadrisulcatus, Thurmanniceras* cf. *thurmanni, ?Thurmanniceras perispinctoides* (Uhlig), *Kilianella* ex gr. *roubaudiana, K. clavicostata, Busnardoites campylotoxus* (Uhlig), *Fuhriella michaelis* (Uhlig), *F. hystricoides* (Uhlig), *F. hoheneggeri* (Uhlig), *Neocomites neocomiensis, N. teschenensis, Teschenites callidiscus* Thieuloy, *T. scioptychus* (Uhlig), *T. paraplesius* (Uhlig), *T. neocomiensiformis* (Uhlig), *Olcostephanus (O.)* cf. *astierianus* (d'Orbigny), *Platylenticeras* cf. *heteropleurum* (Neumayr & Uhlig), *Pl. pseudograsianum* (Uhlig), *Platylenticeras* sp. and *Bochianites neocomiensis*. The specimens of *"Hoplites" austrosilesiacus, "Ptychoceras" teschenense* and a few others described by Uhlig (1902) have not been preserved in the collections, so their revision and assignment according to the present day system is not possible.

The above mentioned ammonite association from the basinal Godula development is relatively distinct from the similarly aged, above described association of the Baška development. Considering the fact that the position of finds in the stratal sequence of the lower part of the Těšín-Hradiště Formation is not known, its stratigraphic value could only be derived on the basis of published data.

The Early Valanginian is well documented by platylenticeratids, and the zonal species *Busnardoites campylotoxus*, the index value of which, like the stratigraphic position of the genus *Fuhriella* Bulot (see Bulot et al. 1995), was distinguished only supplementarily. In the Late Valanginian dominated representatives of the genus *Teschenites* Thieuloy, while the prodichotomitids, *Saynoceras verrucosum* and others guide fossils known from Štramberk were not registered. Likewise in the previous development, the weak representation of the suborder Ancyloceratina is striking. The index elements of the Early Hauterivian do not occur in this collection.

Many richer finds of ammonites come from the upper part of the Těšín-Hradiště Formation, which were systematically studied by Uhlig (1883 — Wernsdorfer Schichten) in the last century. Finally Vašíček revised and supplemented them by his own collection (1972, 1973; Vašíček et al. 1994 and others). The above mentioned formation is evidently represented mostly by distal turbidites.

Up to the present day, ammonites have been found in small, usually temporary natural outcrops, or in small dumps after the historic extraction of irostones. They are preserved in pelites crushed to the level of the bedding plane. They occur in isolated and usually distant horizons, which are only a few centimetres thick. The ammonites are relatively rarely accompanied by sporadic valves and shells of bivalves, gastropods and sometimes also remnants of dry land plants. As a result of the unfavourable exposure of the formation, in which, as was al-

ready indicated, continuous sections are not available, the sequence and actual composition of the ammonite associations in the whole stratal sequence of the Těšín-Hradiště Formation can only be indirectly deduced.

The fossiliferous deposits characterized in the previous paragraph begin in the Early Barremian. The underlying Late Hauterivian components are not documented by ammonites. The following association dates from the Early Barremian (species marked by * pass into the Late Barremian): *Phylloceras (Hypophylloceras)* ex gr. *thetys* (d'Orbigny)*, *Partschiceras infundibulum* (d'Orbigny)*, *Lytoceras* aff. *subfimbriatum* (d'Orbigny), *L. textum* Vašíček, *Eulytoceras anisoptychum* (Uhlig), *Protetragonites crebrisulcatus* (Uhlig)*, *Macroscaphites binodosus* Uhlig, *Barremites psilotatus* (Uhlig), *Melchiorites lechicus* (Uhlig), *Holcodiscus* ex gr. *caillaudianus* (d'Orbigny), *Silesites vulpes* (Coquand), *Nicklesia* cf. *pulchella* (d'Orbigny), *Acrioceras* cf. *tabarelli* (Astier), *Hamuliana astieriana* d'Orbigny, *H.* cf. *alpina* d'Orbigny, *Anahamulina hoheneggeri* (Uhlig), *A. ptychoceroides* Uhlig, *A.* cf. *paxillosa* (Uhlig), *Crioceratites* cf. *thiollierei* (Astier), *Hamulinites parvulus* (Uhlig), *H. fragilis* (Uhlig), *Karsteniceras pumilum* (Uhlig), *K. subtile* (Uhlig), *Eoheteroceras uhligi* (Vašíček), *E. silesiacum* Vašíček & Wiedmann, *Manoloviceras saharievae* (Manolov), *Acantholytoceras longispinum* Uhlig*, *Paraspiticeras pachycyclum* (Uhlig) and others.

The index spitidiscids or ammonite species which would unambiguously prove the earliest Barremian (Hugii Zone) are absent from the determined material, although the stratal sequence from the Hauterivian is uninterrupted. The zonal ammonites of the upper part of the Early Barremian are also lacking (pulchelliids are quite rare, holcodiscids are sporadic). However, the spectrum of species in which heteromorph ammonites, especially leptoceratoids dominate, corresponds to both the Early Barremian Nicklesi Zone and the Caillaudianus Zone.

A significant genus and species diversity also characterizes the Late Barremian (the species marked by * pass from the Late Barremian to Early Aptian): *Partschiceras bontshevi* (Manolov)*, *Sowerbyceras (Holcophylloceras) ernesti* (Uhlig), *Eulytoceras phestum* (Matheron)*, *Costidiscus recticostatus* (d'Orbigny)*, *C. olcostephanoides* Uhlig*, *Macroscaphites yvani* (Puzos)*, *Pseudosaynella strettostoma* (Uhlig)*, *Pseudohaploceras liptoviense* (Zeuschner)*, *Valdedorsella visulica* (Uhlig), *Silesites seranonis* (d'Orbigny), *Heinzia lindigi* (Karsten), *H. provincialis* (d'Orbigny), *Emericeras hammatoptychum* (Uhlig), *Audouliceras fallauxi* (Uhlig), *Anahamulina distans* Vašíček, *A. beskydensis* Vašíček, *A. rothi* Vašíček, *A. glemmbachensis* Immel, *Ptychoceras puzosianum* d'Orbigny, *P. morloti* Ooster, *P. dittleri* Vašíček, *Heteroceras* sp., *Argvethites* sp., *Spinocrioceras amadei* (Uhlig), *S. trachyomphalus* (Uhlig) and others.

The rich Late Barremian ammonite assemblages of the Těšín-Hradiště Formation also differ significantly from the ammonite spectrum of classic Mediterranean regions. The lower parts of the Late Barremian (Vandenheckei and Sartousiana Zones) show more abundant heteromorphs, especially representatives of the genus *Anahamulina*. The guide genus *Heinzia*, which addmitedly occurs only rarely, is also important. In the upper part of the Barremian, with one exception (*Argvethites*), the guide *Colchidites* are missing, so that for the highest two Barremian zones can be identified mainly according to the occurrence of the species *Silesites seranonis* and the absence of the above mentioned heteromorphs. After thirty years of collection in the Silesian Unit, it is only possible to state that the Late Barremian as substage is easily distinguishable, where some of the representatives of the genus *Costidiscus* occurs together with *Silesites seranonis*. Used ammonite zones, however, cannot be applied yet.

The Těšín-Hradiště Formation continues in the same facies into the Aptian. The Early Aptian is documented by: *Partschiceras baborense* (Coquand), *Costidiscus microcostatus* (Sim., Bac. & Sorokin), *Procheloniceras albrechtiaustriae* (Uhlig), *P. pachystephanum* (Uhlig), *Cheloniceras* aff. *seminodosum* (Sinzow), *?Prodeshayesites* sp., *Deshayesites beskidensis* (Uhlig), *D. borowae* (Uhlig), *Acrioceras karsteni* (Uhlig) and others. With regard to the endemic deshayesitids, it is not also possible to use the standard Mediterranean zones for the Early Aptian in the Těšín-Hradiště Formation. *Procheloniceras albrechtiaustriae* plays the leading role here. The fossiliferous deposits evidently correspond only to the basal part of Aptian.

The Late Aptian deposits in the Těšín-Hradiště Formation, except the only faunal horizon that has been found so far (Vašíček 1981), do not contain ammonites. Among the sporadically occurring ammonites, *Acanthohoplites nolani exiquecostatus* Egoian has the index role, indicating the Late Aptian Nolani Zone.

The Pieniny Klippen Belt

The Pieniny Klippen Belt (PKB) is tectonically the most complicated part of the Western Carpathians. To the Lower Cretaceous belong the light coloured limestones, frequently with cherts. In some localities, they are rich in fossils. We have carried out systematic collecting in the Klippen Belt only in recent years, and so far the localities in the sector from Podbranč in the south to Podbiel in the north have been studied. At natural exposures and in some quarry faces, it was possible to some extent to collect ammonites, by means of the bed by bed method, largely from the debris below the faces. However in the second case, with a mostly steep inclination of strata, the majority of finds more or less correspond to their actual position in the sequence of strata.

The oldest stratigraphically proved occurrences of ammonites in the PKB belong to deposits around the boundary between the Early and Late Valanginian and the Late Valanginian. They include: *Partschiceras winkleri* (Uhlig), *Phylloceras (H.)* ex gr. *thetys*, *Phylloceras* cf. *ptychostoma* (Benecke), *Protetragonites quadrisulcatus, Neolissoceras grasianum, Neocomites platycostatus* (Sayn), *N. teschenensis, N. praediscus* Reboulet, *Jeanthieuloyites* cf. *quinquestriatus* (Besaire), *Olcostephanus* cf. *detonii* (Rodighiero), *Olcostephanus* sp., *Valanginites nucleus* (Roemer), *Oosterella* ex gr. *gaudryi* (Nickles), *Himantoceras trinodosum* Thieuloy, *Bochianites neocomiensis, B. oosteri* Sarasin & Schoendelmayer and others. These are entirely new, previously unpublished finds. The occurrence of the genus *Oosterella* is notable, since it does not occur in other Carpathian units.

The zone species of the basal part of the Late Valanginian, that is *Saynoceras verrucosum*, is lacking as it is usual in pelagic deposits. This zone is, however, indicated by the occurrence of *Neocomites platycostatus* and *N. teschenensis*. The overlying Trinodosum Zone is directly documented by the zone species, resp. by *N. praediscus*. The latest Valanginian zone (Callidiscus) is not unambiguously documented. It could be indicated by a specimen determined as *Teschenites* cf. *castellanensisformis* Reboulet, which occurs in the Vocontian Trough around the Valanginian/Hauterivian boundary (Reboulet 1995).

The Early Hauterivian is represented by: *Lytoceras subfimbriatum, Neolissoceras grasianum, Teschenites flucticulus* Thieuloy, *Spitidiscus* cf. *rotula* (Sowerby), *Olcostephanus* sp., *Crioceratites loryi* Sarkar, *C. nolani* (Kilian), *Abrytusites thieuloyi* Vašíček & Michalík, *Bochianites oosteri, Olcostephanus (J.) jeannoti* (d'Orbigny) and other. The last datum is from Andrusov & Scheibner (1960). The determined species indicate the Radiatus Zone (*T. flucticulus*) and the Loryi Zone. The Nodosoplicatum Zone, which is documented least, could be indicated by *A. thieuloyi*.

The Late Hauterivian is shown by *Subsaynella sayni* (Paquier), *Crioceratites* ex gr. *duvali* (Léveillé), *Plesiospitidiscus* sp., *Crioceratites binelli* sensu Thomel, *Ptychoceras borzai* Vašíček & Michalík (which is perhaps a synonym of *Ptychoceras meyrati* Ooster), *Pseudothurmannia* sp. The Sayni Zone is proved by the zone species, while there is indirect evidence of the overlying Ligatus and Balearis Zones.

The Barremian deposits are only poorly shown by finds of *Barremites* sp.

The Central Carpathians

The Manín Nappe

In contrast with the Outer Carpathians there are some localities in the Lower Cretaceous where collecting is possible by the bed by bed method within the extent of two to three stratigraphic stages. They are mostly represented by extensive quarry faces in quarries where light marly limestone is extracted as a raw material for cement. However, these quarry profiles are usually only temporary exposures.

In the Manín Unit, the Butkov quarry near the Ladce cement works in the Váh area represents a locality with extensive quarry faces and suitable, although in places tectonically considerably affected sections. From its quarry faces, which owing to the permanent exploitation largely do not exist at present, several hundred ammonites documenting the stratal sequence in the range from the Early Valanginian to Late Barremian have been collected. In the mentioned deposits the benthos occurs only very sporadically.

The ammonite fauna, sections from the Butkov quarry and a sequence of found ammonites from the Early Valanginian to Late Barremian are described by Vašíček & Michalík (1986), Vašíček et al. (1994) and Vašíček (1995). The uppermost Early Valanginian (Campylotoxus Zone) is documented by the *Busnardoites campylotoxus* and *Neolissoceras salinarium*; the last one being described later in Michalík et al. (1995). In deposits corresponding to the Verrucosum Zone *Saynoceras verrucosum* has not been found. In spite of this it is however indicated by the occurrence of *Neocomites teschenensis.* The overlying zone is documented well not only by the zone species *Himantoceras trinodosum* but also by another index species *Olcostephanus nicklesi* Wiedmann & Dieni, *Teschenites subflucticulus* Reboulet, *Criosarasinella furcillata* Thieuloy and *C. heterocostata* (Mandov). In the contribution by Vašíček & Michalík (1986), the latter species is considered to be an equivalent of the Callidiscus Zone. However, as documented by Bulot & Thieuloy (1995), the occurrence of the genus *Criosarasinella* in France ends already in the Trinodosum Zone. More numerous finds of the genus *Eleniceras* Breskovski and finds from the range of *Teschenites neocomiensiformis* (Uhlig) correspond probably to the latest Valanginian (Callidiscus Zone).

Hauterivian deposits, with the exception of the lower part, are poorer in ammonites. The basal Hauterivian is indicated by the only fragment of *Acanthodiscus* sp., more frequent teschenites, whose precise determination, or revision should ensue, *Spitidiscus* ex gr. *rotula, Lytoceras lepidum* (d'Orbigny), *Neolissoceras desmoceratoides* Wiedmann, and others. The following occur somewhat higher: *Partschiceras infundibulum, Jeanthieuloyites nodosus* (Mandov), *Spitidiscus cankovi* Vašíček & Michalík, *Abrytusites thieuloyi* Vašíček & Michalík, *Crioceratites nolani, Cr. loryi, Eleniceras* sp. and others. With regard to the occurrence of *Cr. loryi*, this is a case of association of the Loryi Zone. The Nodosoplicatum Zone has not been documented yet.

The Late Hauterivian in the Manín Unit, with a single exception, lacks zonal ammonites. It is documented especially by: *Crioceratites duvali* (Léveillé), *Plesiospitidiscus ligatus* (d'Orbigny), *Spitidiscus fasciger* Thieuloy and *Ptychoceras borzai* Vašíček & Michalík. As a result of the rareness of the finds, it is difficult to identify the Hauterivian/Barremian boundary.

The Early Barremian is indicated only by more abundant occurrences of imperfectly preserved barremitids and occasional finds of *Psilotissotia favrei* (Ooster), *Pulchellia* cf. *compressissima* (d'Orbigny), *Hamulinites* cf. *parvulus, Anahamulina* sp. and others. Finally there are sporadic occurrences of *Holcodiscus* ex gr. *perezianus* (d'Orbigny), *Valdedorsella uhligi* (Haug). The abundance of barremitids continues further.

The boundary between the Early and Late Barremian is unidentifiable as a result of the rareness of ammonites. A single find of *Costidiscus recticostatus* (d'Orbigny) in the beds below the massive limestones of the prograding carbonate platform (which already does not contain ammonites), shows that the uppermost part of the marly limestones of the underlying stratal sequence still belongs to the lower part of the Late Barremian.

The Krížna Nappe — Zliechov Basin

The Lower Cretaceous deposits of the Krížna Nappe have a relatively large areal extent in the Central Carpathians (Vašíček et al. 1994). With the exception of the latest Hauterivian, where brachiopods occasionally occur, these deposits generally contain few benthic organisms. In many places,

especially in deposits of the Late Hauterivian, they contain ammonites.

The pelagic deep water deposits of the Early Valanginian are usually very poor in benthonic organisms and also in ammonites, which is also largely true of the Late Valanginian. Only in places in the Late Valanginian occur rich associations of straight shells of the species *Bochianites neocomiensis* and *B. oosteri* accompanied by rare *Neocomites teschenensis, N.* ex gr. *neocomiensis*, *Neolissoceras grasianum, Protetragonites quadrisulcatus, Paquiericeras (Julianites)* cf. *undulatum* Thieuloy and *Olcostephanus* sp. (Borza et al. 1981). In the Strážovce section (Borza et al. 1980; Vašíček et al. 1994), stratigraphically important *Himantoceras trinodosum* and *Criosarasinella* ex gr. *mandovi* Thieuloy were also successfully found.

The rich (that is in number of finds) Early Hauterivian was studied at an isolated outcrop in the Košecká dolina Valley. The following ammonites occur: *Neolissoceras grasianum, Spitidiscus* ex gr. *rotula*, *Olcostephanus hispanicus* (Mallada), *Teschenites* sp., *Crioceratites nolani, Bochianites oosteri*, which indicate the deposits near the Loryi Zone. The Nodosoplicatum Zone is not documented by ammonites.

The basal part of the Late Hauterivian is indicated by a single occurrence of the zone species *Subsaynella sayni* at the locality of Kamenná hill (Sayni Zone). The upper part of the Late Hauterivian is already documented at a whole series of localities, but best is documented in the deposits exposed by quarry faces at Polomec hill at Lietavská Lúčka (Vašíček et al. 1994; Vašíček 1995). The marly limestones extracted as raw material for cement are limited with turbidites at the base, the top of which is very probably situated around the boundary between the ammonite zones Sayni and Ligatus. The ammonites *Plesiospitidiscus* ex gr. *ligatus* and *Ptychoceras borzai*, or *Acrioceras pulcherrimum* (d'Orbigny), *A. mulsanti* (Astier), *Crioceratites matsumotoi* Sarkar, *Neolissoceras grasianum* are characteristic of the limestones in the beds overlying the turbidites. They are an evidence of the Ligatus Zone.

Apart from the above mentioned ammonites, the overlying deposits are enriched with further species, especially with rare finds of *Pseudothurmannia balearis* (Nolan), *P. binelli* sensu Thomel, *P. mortilleti* (Pictet & Loriol), *P. shankariae* (Sarkar), *Crioceratites majoricensis* (Nolan), *Acrioceras seringei* (Astier) — when the genus approach to pseudothurmanniids in the wider sense of the word corresponds to the results of Hoedemaeker (1995). This collection belongs to the Balearis Zone.

The next stratal sequence, after an interruption of several metres, is unusually rich in ammonites for the Western Carpathians. Together with the species mentioned in the previous paragraph (with the exception of *Pseudothurmannia shankariae*), *Partschiceras infundibulum, Neolissoceras grasianum, Plesiospitidiscus subdifficilis* (Karakasch), *Barremites* sp., *Psilotissotia favrei, Crioceratites nolani* sensu Adamiková et al., *C. angulicostatus* (d'Orbigny), *Anahamulina subcylindrica* (d'Orbigny), *Paraspiticeras* sp. and others occur.

The Early Barremian is associated with the extinction of pseudothurmanniids and crioceratitids, and with the development of barremitids. Together with them, there are also smaller quantities of juvenile shells of *Spitidiscus* ex gr. *hugii* (Ooster), as well as *S. seunesi* (Kilian), *Silesites vulpes, Veveysiceras escheri* (Ooster), *Hamulinites* ex gr. *parvulus*, *Hamulina lorioli* Uhlig, *Acrioceras* aff. *puzosianum* (d'Orbigny), *Anahamulina* sp. and others. This association especially indicates the Hugii Zone.

Together with barremitids, the more marly overlying deposits contain: *Costidiscus recticostatus, Macroscaphites yvani, Silesites seranonis, Eulytoceras phestum, Anahamulina* cf. *glemmbachensis*. The assemblage corresponds to the lower part of the Late Barremian.

By the end of the Late Barremian, limestone sedimentation is replaced by a facies of marlites, without direct faunistic continuation of the previous stratal sequence. They contain the ammonites: *Costidiscus tenuistriatus* (Repelin), *Macroscaphites striatisulcatus* (d'Orbigny), *Deshayesites* sp. and others. The ammonite composition corresponds to one of the nearly undistinguishable zone of the Early Aptian (Vašíček & Rakús 1995).

Conclusion

Both the review of the ammonite-bearing formations of the geological units of the Western Carpathians arranged generally from north to south, and their ammonite composition show on the one hand significant unevenness in the occurrence of fossiliferous formations in the Carpathian sedimentary basins in the course of the Lower Cretaceous, and on the other hand significant differences in the genus and species composition of the ammonites. The significant differences are probably caused by a whole series of factors, especially by the paleo-geographical position of the individual basins, the dynamics of sedimentation and facial differences.

The greatest facial differences are perceptible in the lithological character of the Lower Cretaceous deposits of the Silesian Unit and the remaining sedimentation basins. Dark grey flyschoid, more or in higher parts less calcareous pelites with significant flysch sedimentation in the Hauterivian, and a total thickness of the deposits of around 1 km are typical of the Silesian Unit. On the other hand, in the other described basins (PKB and in the Central Carpathians), pelagic limestone facies with thicknesses of the Lower Cretaceous of little more than 100 m are dominant.

The whole extent of the Valanginian (that is Early and Late) is documented by ammonites only in the Silesian Unit. Although Mediterranean genera and species dominate here, boreal elements occur occasionally although rarely. The Early Valanginian contains representatives of the genus *Platylenticeras*, and the Late Valanginian, the genus *Prodichotomites*. While the former genus is represented in both partial developments of the Silesian Unit, the latter is known only from the area of the Baška Ridge. This is also marked as the beginning of the Late Valanginian by the occurrence of *Saynoceras verrucosum* and some representatives of the genus *Valanginites*. The Valanginian boreal elements show periodic communication of the Silesian sedimentary area through the Danish-Polish depression with the sub-boreal area in Germany (Witkowski 1969; Kutek et al., 1989; Marek 1989).

In the carbonate developments of the Valanginian in the PKB, only the Late Valanginian is documented by ammonites, while in the Central Carpathians the Late Valanginian occurs usually together with the imperfectly documented Early Valanginian. The ammonites found here represent only the Mediterranean bioprovince. Platylenticeratids or other boreal forms are not found in any of these sedimentary areas from the Early Valanginian. Similarly *Prodichotomites* and other boreal elements are not known from the Late Valanginian. A find of the only shell of the genus *Valanginites* at the Revišné locality in the PKB is a small unproved exception.

Among the zonal Mediterranean species of the Early Valanginian, only *Busnardoites campylotoxus* is known from the Silesian Unit (Godula Development) and from the Manín Unit. Both Reboulet (1995) and Bulot & Thieuloy (1995) have recently cast doubt on the the index value of *Neolissoceras salinarium*, which in Spain according to Company (1987) has a guide value corresponding to the previous species. In France this species, known from both the above mentioned Carpathian units, occurs in the whole Early Valanginian, and extends up to the base of the Late Valanginian.

All the basic zonal species are documented from the Late Valanginian in the Western Carpathians, but they are found sporadically and only in some Carpathian sedimentation areas: *Saynoceras verrucosum* is documented only in the Baška development of the Silesian Unit, *Himantoceras trinodosum* occurs in the PKB, Manín Unit (where the Nicklesi and Furcillata bio-horizons are also documented) and in the deposits of the Krížna Nappe. *Teschenites callidiscus* is known only as a single historical find (today not preserved) from the Godula development, described by Uhlig (1902).

Bulot & Thieuloy (1995) still conveniently designate individual parts of the Valanginian in the Vocontian Trough according to the dominant genus: the Early Valanginian as Thurmanniceratian, the Verrucosum Zone as Karakaschiceratian, the remnant of the Late Valanginian as Teschenitian. A very rich representation of olcostephanids is also characteristic of the upper part of the Early Valanginian (Zone with *Olcostephanus stephanophorus*) and the Verrucosum Zone as well in the Vocontian Trough (Bulot 1993). It is necessary to remark here that the above mentioned dominant faunas or genera in the classic area of the Vocontian Trough usually do not represent the dominant elements in the Western Carpathians. The thurmanniceratids, olcostephanids and karakaschiceratids are represented only occasionally to rarely (the last of them). Carpathian shells of the genus *Olcostephanus* are always strongly deformed and difficult to determine.

The Hauterivian is a stratigraphic stage, which is as a whole less documented in the Western Carpathians. In the Baška development of the Silesian Unit, only the basal part of the Hauterivian is documented by the occurrence of strongly deformed incomplete shells of the guide genus *Acanthodiscus*. They are accompanied by equally badly preserved fragments of shells of the genus *Endemoceras*, which show repeated communication of the Silesian sedimentary area with the boreal region. In the deposits of the Godula development, the Hauterivian is documented only by occasional finds of ammonites. This is apparently connected with tectonic movements, which are reflected in a significant representation of sandstones in the proximal turbidites of the Silesian Unit, or maybe in the Hauterivian turbidites in the Krížna Nappe or in the dark pelites replacing the carbonates at some localities in the PKB (Horné Srnie).

The lower part of the Early Hauterivian is usually well documented in the PKB. The Loryi Zone is documented by the zone species. The Nodosoplicatum Zone is not reliably proved, but the base of the Late Hauterivian is documented by a find of the zone species *Subsaynella sayni*. The higher part of Late Hauterivian contains few ammonites with the last disappearing around the boundary between the Balearis and Angulicostata Zones. The situation is similar in the Manín Unit. The lower part of the Early Hauterivian (including the Loryi Zone) is still rich in ammonites. The Nodosplicatum zone is not documented by ammonites: the Late Hauterivian with occasional finds lacks the zonal ammonites (but a single occurrence of *Plesiospitidiscus* ex gr. *ligatus*).

With a few exceptions, the Early Hauterivian is imperfectly documented in the deposits of the Krížna Nappe. After a part without ammonites corresponding to the Nodosoplicatum Zone, ammonite finds rapidly increase. This culminates in the Angulicostata Zone in the form of the so-called Pseudothurmannia beds. All the Late Hauterivian ammonite zones are documented: Sayni, Ligatus, Balearis and Angulicostata. Since the beds below the above mentioned Pseudothurmannia beds usually contain *Ptychoceras borzai*, we have proposed a Borzai ammonite Zone in the Late Hauterivian in the Western Carpathians (Vašíček et al. 1994; Vašíček 1995). With regard to the latest data from the PKB, and also our own collections in the Eastern Alps in 1996, it is probable that *Ptychoceras borzai* is a synonym of *P. meyrati* Oost-er (this may also include *P. curnieri* Thieuloy). Its occurrence is not limited only to the Late, but also to a substantial part of the Early Hauterivian. So the introduction of this zone into the Western Carpathians seems to be inappropriate.

The deposits of the uppermost Hauterivian Zone are perhaps the richest formation of the Western Carpathians for ammonites. However in spite of this, they do not contain the subzonal ammonites *Pseudothurmannia ohmi* and *P. catulloi* assigned by Hoedemaeker (1995). In the general composition

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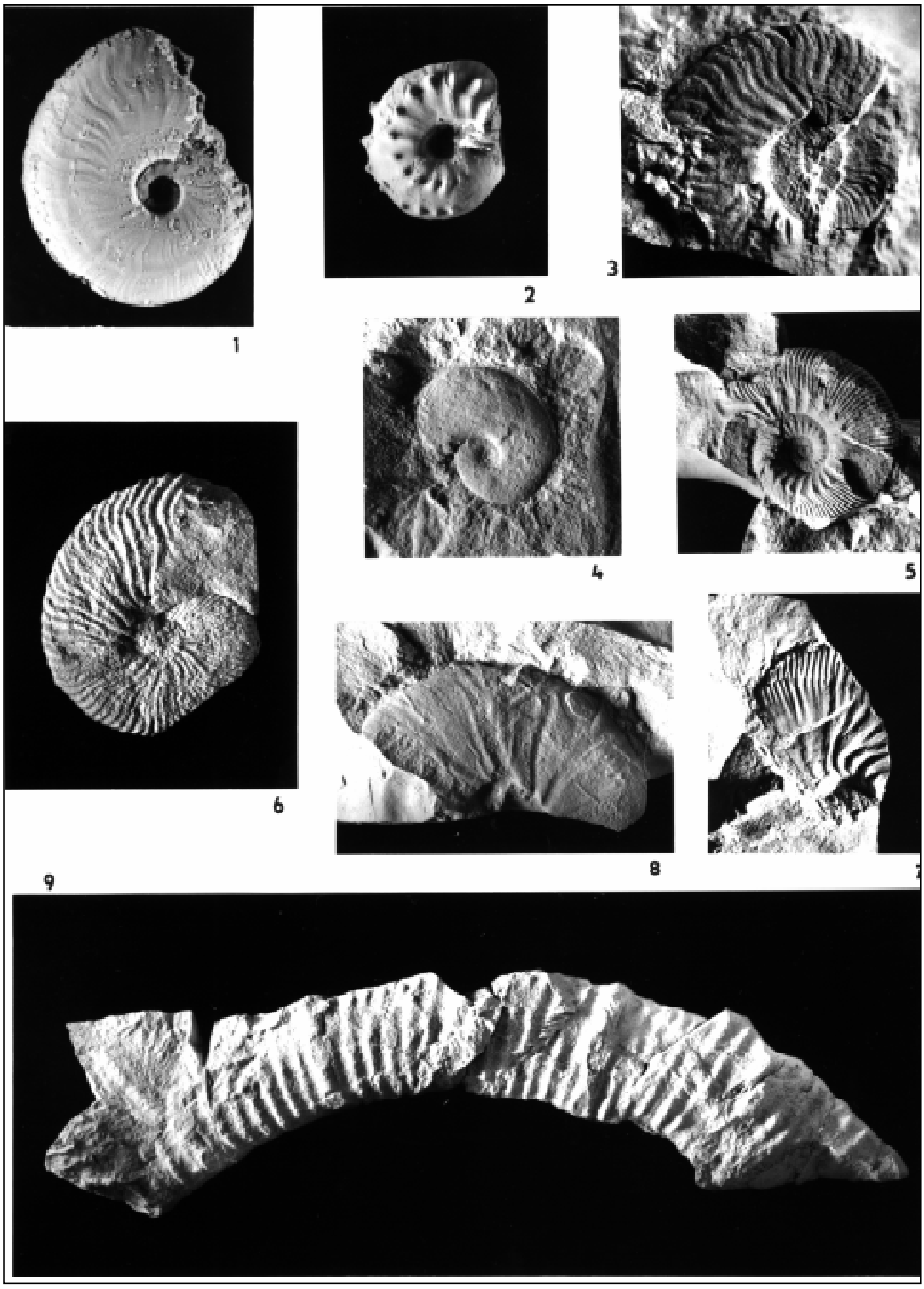
Plate I: Fig. 1. *Platylenticeras cardioceroides* (Sayn), ×2. Silesian Unit, Kotouč quarry, Šramberk, layer Š-12. Early Valanginian, Pertransiens Zone. **Fig. 2.** *Saynoceras verrucosum* (d´Orbigny), ×3. Silesian Unit, Kotouč quarry, layer Š-55. Late Valanginian, Verrucosum Zone. **Fig. 3.** *Busnardoites campylotoxus* (Uhlig), ×1. Manín Unit, Butkov quarry, 8th level, 560 m. Early Valanginian, Campylotoxus Zone. **Fig. 4.** *Neolissoceras salinarium* (Uhlig), ×1.5. Manín Unit, Butkov quarry, 13th level. Early Valanginian, ?Campylotoxus Zone. **Fig. 5.** *Olcostephanus nicklesi* Wiedmann & Dieni, ×1. Manín Unit, Butkov quarry, 12th level. Late Valanginian, Trinodosum Zone. **Fig. 6.** *Teschenites flucticulus* Thieuloy, ×1. Pieniny Klippen Belt, Podbiel Klippe in the Orava Valley. Early Hauterivian, Radiatus Zone. **Fig. 7.** *Prodichotomites* ex gr. *complanatus* (Koenen), ×1. Silesian Unit, Kotouč quarry, layer Š-55. Late Valanginian, Verrucosum Zone. **Fig. 8.** *Plesiospitidiscus* sp., ×1. Krížna Nappe, Laz quarry at Lietavská Lúčka, cover of turbidite. Late Hauterivian, Ligatus Zone. **Fig. 9.** *Himantoceras trinodosum* Thieuloy, ×1. Pieniny Klippen Belt, Revišné Klippe. Late Valanginian, Trinodosum Zone.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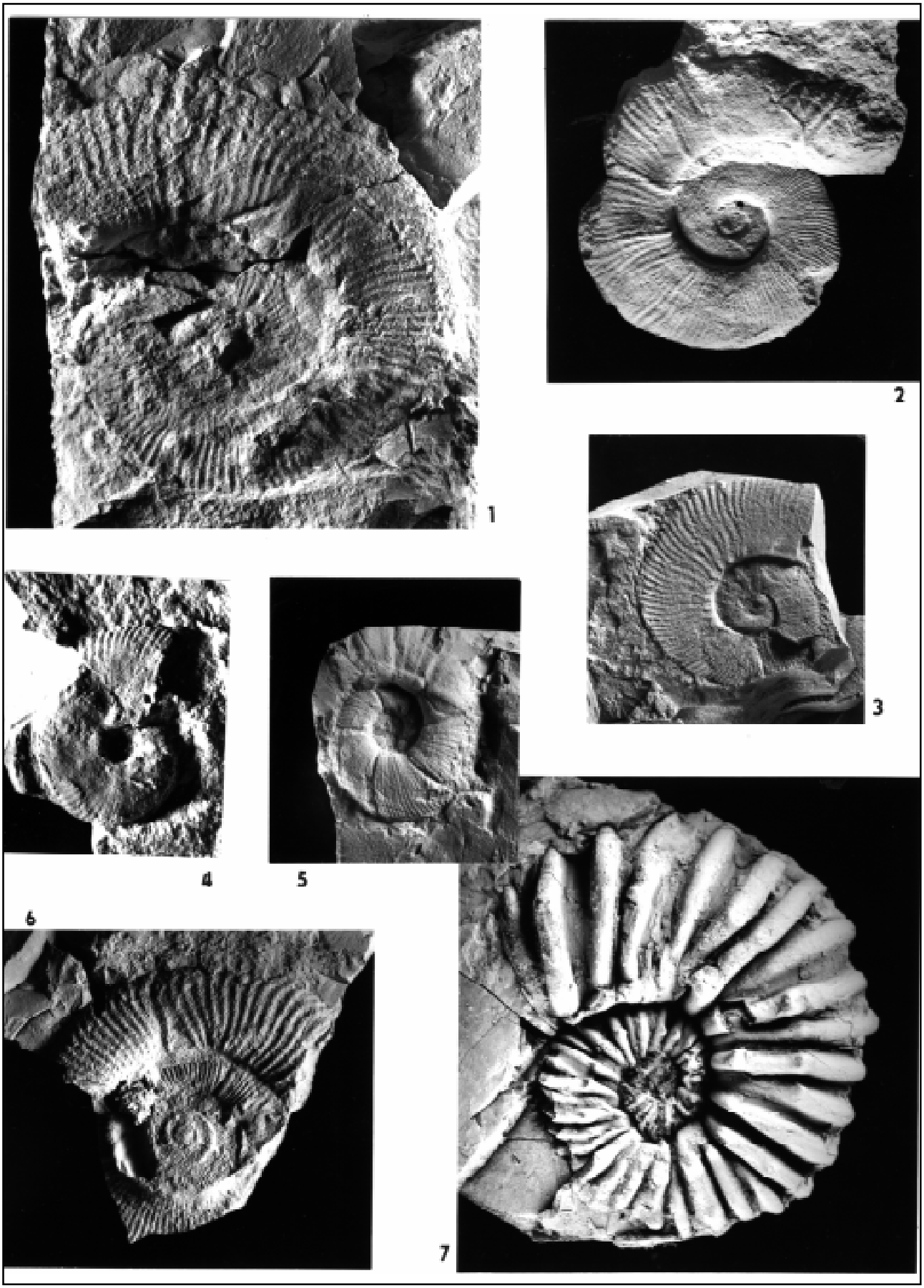
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of this ammonite association, it is possible to observe substantial differences in comparison with the classic Mediterranean regions, which is however also characteristic of the underlying and overlying Carpathian deposits. Therefore the exact application of Hoedemaeker's above mentioned subzones is still not possible in the Western Carpathians.

The Barremian associations in the Western Carpathians have an entirely Mediterranean character, since the communication of the Silesian sedimentary area with the boreal region via the Danish-Polish Depression was already interrupted in the Hauterivian. In spite of the considerable abundance of ammonites in the Barremian of the Silesian Unit, application of the Mediterranean zones in the Western Carpathians remains difficult. However it is relatively easy to distinguish the Barremian substages, where abundant leptoceratoids occur in the Early Barremian. The Late Barremian is characterized especially by the occurrence of *Costidiscus recticostatus* together with *Silesites seranonis*. In the area of the Central Carpathians, the situation in the Barremian is similar. In the Krížna Nappe, only the Hugii Zone could be perhaps applied.

Richer ammonite associations of the Aptian occur in the Western Carpathians only in its lower parts of some units. In the Silesian Unit, the occurrence of *Procheloniceras albrechtiaustriae* at the base of the given stage is most characteristic. Deshayesitids, if they occur, are not usually well preserved and are endemic. The standard ammonite zones cannot be precisely applied. The Late Aptian in the deposits of the Western Carpathians only exceptionally contains ammonites.

This paper reflects the present state and possibilities of ammonite stratigraphy in the Lower Cretaceous of the Western Carpathians. Photographic plates I and II illustrate the Lower Cretaceous guide species.

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Plate II: Fig. 1. *Crioceratites loryi* Sarkar, ×1. Pieniny Klippen Belt, Podbiel Klippe. Early Hauterivian, Loryi Zone. **Fig. 2.** *Pseudothurmannia balearis* (Nolan), ×1. Krížna Nappe, Polomec quarry at Lietavská Lúčka, 4th level, 40 m. Late Hauterivian, Balearis Zone. **Fig. 3.** *Pseudothurmannia mortilleti* (Pictet & Loriol), ×1. Krížna Nappe, Na piate quarry at Lietavská Lúčka, 250 m. Late Hauterivian, Angulicostata Zone. **Fig. 4.** *Subsaynella sayni* (Paquier), ×3. Pieniny Klippen Belt, Podbranč quarry, 1st level. Late Hauterivian, Sayni Zone. **Fig. 5.** *Spitidiscus seunesi* (Kilian), ×1. Krížna Nappe, outcrop on Drienovica hill. Early Barremian, Hugii Zone. **Fig. 6.** *Silesites seranonis* (d´Orbigny), ×1. Tatric, Bralo quarry at Párnica. Late Barremian. **Fig. 7.** *Procheloniceras albrechtiaustriae* (Uhlig), ×1. Silesian Unit, outcrop at Kunčice p. O. Basal Aptian. Photos by K. Mezihoráková and M. Grmelová (Pl. I, Fig. 1 and Pl. II, Fig. 7). Material was bleached with ammonium chloride before photographing.

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