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To the „Neocomian" biostratigraphy in the Krížna-Nappe of the Strážovské Vrchy Mountains (Northwestern Central Carpathians)

By

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With 8 text figures, 1 table and 2 plates

ABSTRACT

The paper deals with the newest results of detailed stratigraphical research in nine Lower Cretaceous sequences in Western Carpathians. The correlation of several parabiostratigraphical schemes based on several groups of organisms, allowed to elaborate a local biostratigraphy, applicable in the whole area, and relatively reliable date most of the lithological horizons. Moreover, the detailed lithostratigraphical correlation enables us to reconstruct sedimentary and paleotectonical development of the Krížna (= Fatric) basin.

KURZFASSUNG

In dieser Arbeit werden die Ergebnisse der biostratigraphischen Untersuchungen in den Ablagerungen des höchsten Jura und der unteren Kreide im Gebiet des Strážov-Berglandes (Krížna-Decke = Fatrikum) vorgestellt. Sie stützen sich auf neun Profile, die lithofaziell und auf ihren Mikroplankton- und Cephalopoden-Inhalt hin untersucht wurden.

Die bisher gewonnenen Ergebnisse zeigen, daß die Entwicklung des Fatrikums komplizierter ist, als bisher angenommen wurde. Die ältesten Ablagerungen der „Neokom"-Schichtenfolge gehen aus silifizierten Tiefwasserkarbonaten hervor. Tithon, Berrias und Untervalangin sind vor allem mikrofaunistisch belegt, die Makrofauna ist gewöhnlich nur durch Aptychen dokumentiert. Obervalangin bis unterstes Apt enthalten stellenweise ziemlich reiche Cephalopodenfaunen, besonders Ammoniten, die mediterranen Charakter besitzen. Höheres Apt und Unteralb läßt sich nur durch Mikroplankton und stellenweise durch orbitolinide Foraminiferen identifizieren.

ACKNOWLEDGMENTS

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1. INTRODUCTION

Lower Cretaceous carbonate sequences form considerable part of the rock sequence in the Krížna nappe of central Western Carpathians (Czechoslovakia). During the last years we happened to enrich our recent knowledge (MICHALÍK & VAŠÍČEK 1979, BORZA et al. 1980, MICHALÍK et al. 1980, VAŠÍČEK & MICHALÍK 1981, BORZA et al. 1982) by adding of further, more completely known new sequences. Our newest localities and the application of several modern literary data (among them BUSNARDO et al. 1979 predominantly) made the knowledge of Upper Valanginian – Upper Barremian interval biostratigraphy more refined.

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Stratigraphical research in the West Carpathian Lower Cretaceous sequences is complicated by an intricated tectonical structure of the terraine, forming a part of the Centrocarpathian nappe front, by lack of completely incovered sections, as well as by its considerable facial variability. This is why our research cannot be considered as to be finished and some of our conclusions as to be definitive. As a result, we could not define ammonite zones, valid in the whole area.

Northwestern part of Strážovské vrchy Mts. forms southern rim of the Middle Váh-river basin (Fig. 1). Complicately deformed frontal part of the Krížna-nappe, extending over great part of this area, consists mostly of Lower- and Middle Cretaceous sediments. In spite of incomplete exposure, several outcrops in quarries, creeks and road's cuts offer possibility of detailed stratigraphical study. This paper is based on the study of nine detailed documented sections, evaluated from both the macro- and micro-lithofacial point of view, according to the content of microplankton and cephalopod macrofauna, as well as nannofloral remains, studied in several places.

2. PALAEOGEOGRAPHICAL SETTING

Mediterranean segment of the Mesozoic Tethys has reached the maximum of its diversification during Late Jurassic and Early Cretaceous. Although the recent knowledge of paleogeographical relations between individual elements of the European Alpides does not allow unambiguous conclusions (cf. Michalík & Kovač 1982), West Carpathian area may be roughly characterized as an extensive, paleogeographically and paleotectonically very diversified area, extending on the west from the mouth of Danish-Polish trough, thus in close neighbourrough of the East European platform (Fig. 2).

The northernmost zone (nowadays Outer Carpathians and Klippen Belt) belonged to the margin of North-European shelf, influenced by Kimmerian tectonic movements. The central West Carpathians, on the other hand, were part of intraoceanic (Kreios) shelf fragment, deformed during Austrian orogenic phase. Both the regions were mutually separated by the Jurassic-Cretaceous Penninic oceanic zone. West Carpathian paleogeographical and paleotectonical development has been strongly influenced by these pecularities.

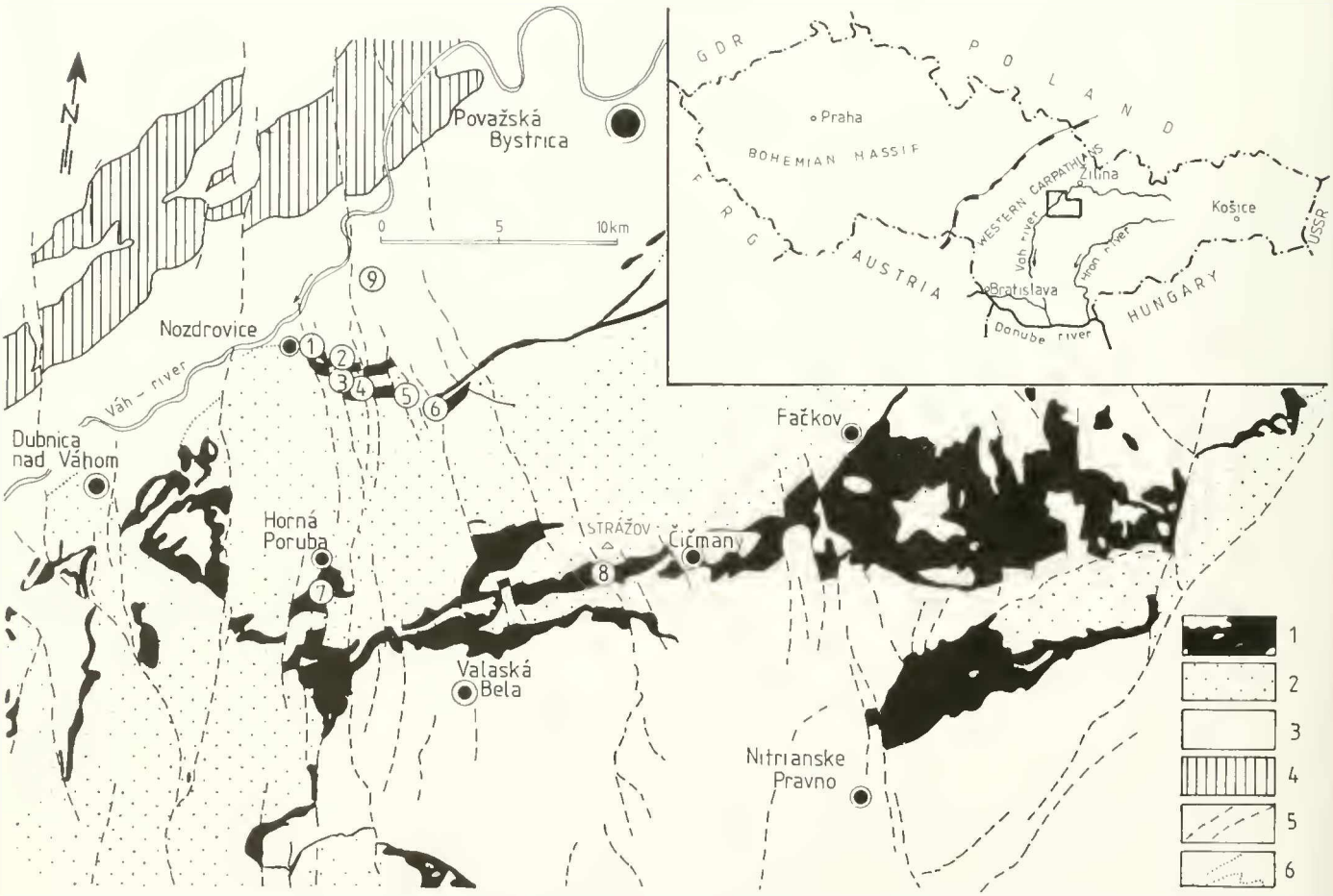

Fig. 1. Geographical localization of studied sections. Legend: 1: Lower Cretaceous deposits of the Krížna-nappe, 2: the same deposits covered by younger sediments or by higher tectonic units, 3: Klippen Belt, 4: faults, 5: limits of distribution of Krížna Lower Cretaceous. Numbers in circles: 1: Nozdrovice section, 2–6: Mráznické lúky sections (2: Kamenná, 3: Pod Stráne, 4: Pod Stupíkmi, 5: Pod Svinorným, 6: Pod Mráznicou, cf. Fig. 6), 7: Horná Poruba section, 8: Strážovce section, 9: Butkov quarry.

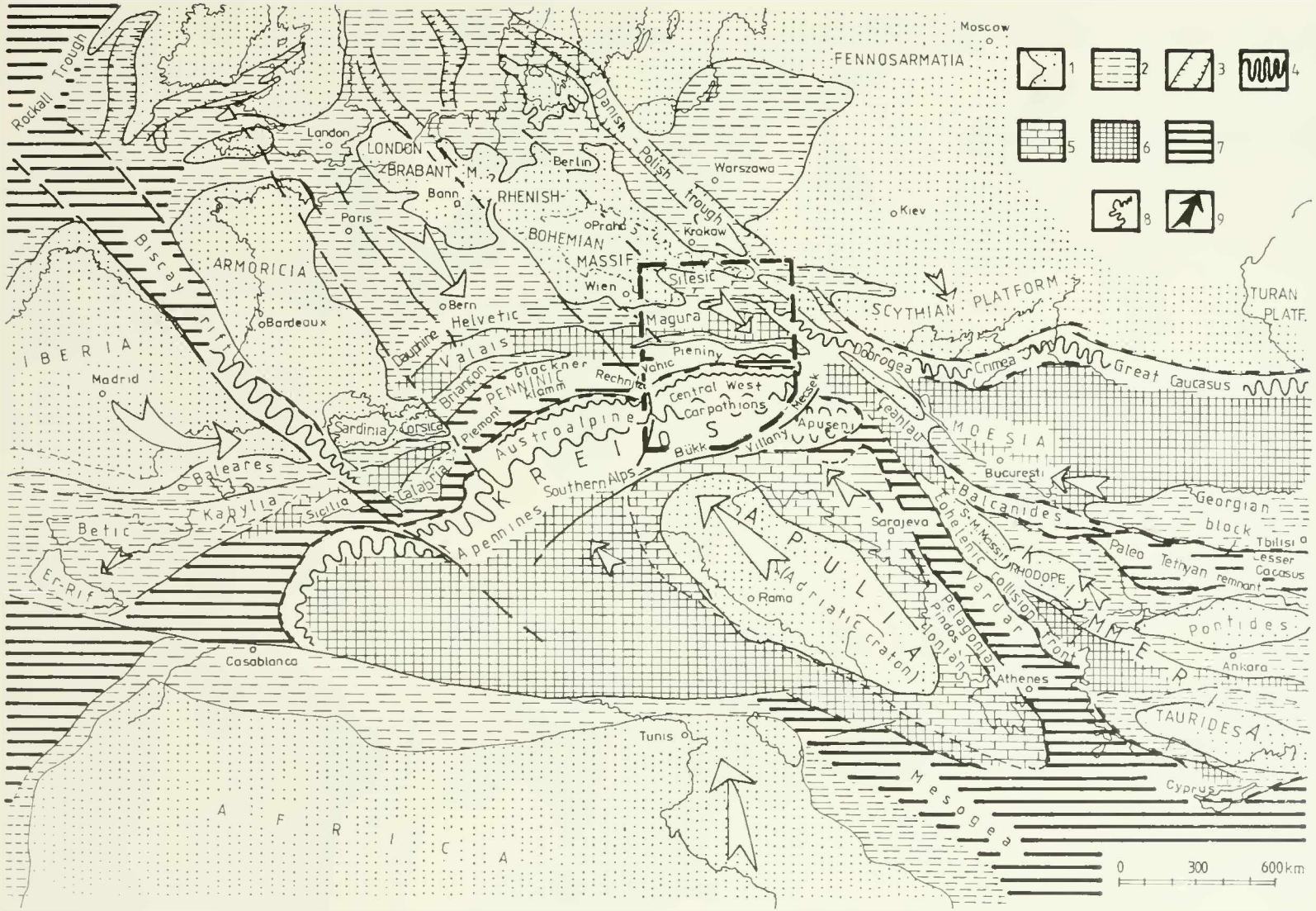

Fig. 2. Albian paleogeographical situation of the Mediterranean Tethys (Michalík & Kováč 1982). West Carpathian area denoted by quadrangle. 1: continental, 2: epicontinental and shelf seas, 3: troughs and rifts, 4: deformed zones, 5: carbonate platforms with adjacent basins, 6: deep-sea basins, 7: oceanic bottom, 8: recent coast-line of Europe and North Africa (for correlation), 9: plate motion vergence.

Sedimentary area of the Centrocarpathian Krížna nappe s. l. (= Fatric according to Andrusov; Pušan & Bystrický 1973) formed part of Jurassic Lower Cretaceous (?back arc) basinal system, separated from the southern border of Pennic ocean by the Tatric zone (Mahel' 1979). The subsidence of this basin, isolated from terrigenous support, considerable accelerated during Callovian and Oxfordian, when thick red and green radiolarite sequence has sedimented here. This sequence indicates "CCD crisis" or the "Jurassic collapse" of Tethys. Its end is dated by finding of *Colomisphaera fibrata* (Nagy) in the uppermost radiolarite layers and in above-lying nodular limestones (Upper Oxfordian). Pelagic carbonate sedimentation gradually stabilized in this basin and the calcitic shell remains became more and more frequently preserved in its sequences.

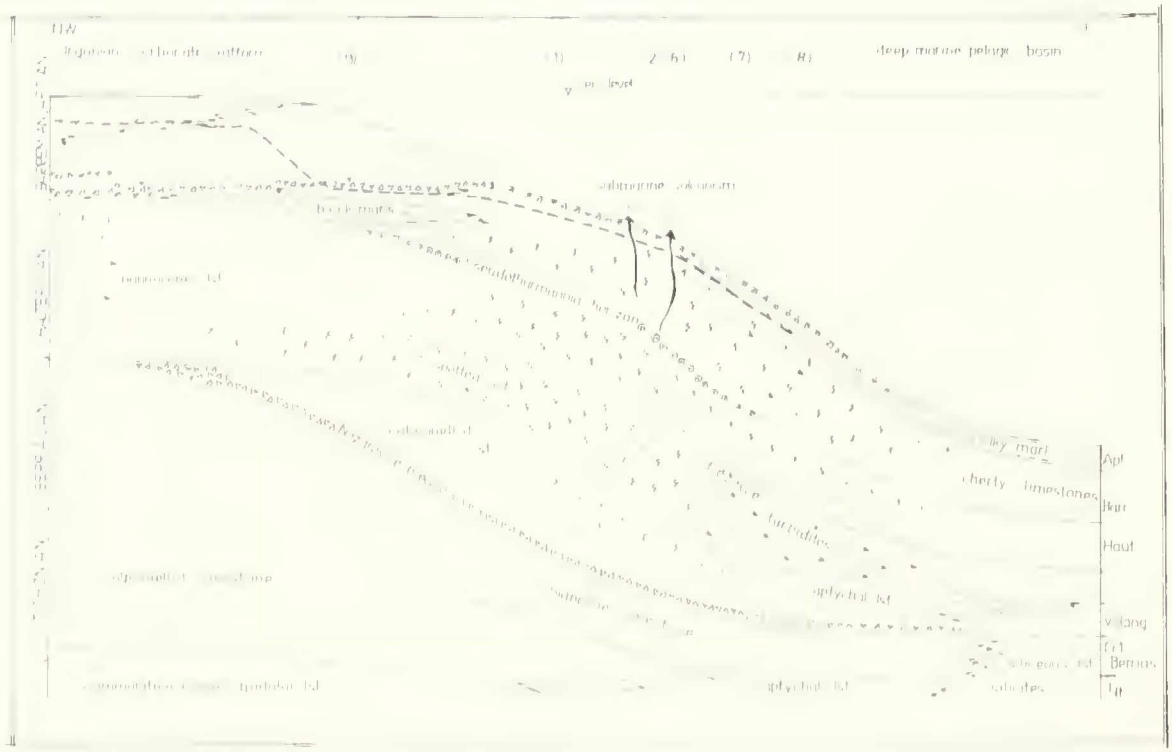

Fig. 3. — Aptian bathymetric scheme of the studied area, along with lithostratigraphy of Lower Cretaceous deposits.

3. STRATIGRAPHY

3.1 UPPER JURASSIC

Sediments of the Jurassic/Cretaceous boundary are very poor in macrofaunal remnants in our sections. Studying this sequence, we must use a parastratigraphical scheme, elaborated on the base of tintinnid and problematic microorganism distribution, as the cephalopod remains (aptychi, ammonites and belemnites) become reliable biostratigraphical tool since Upper Valanginian.

Upper Jurassic sediments were documented in the Strážovce section (loc. 8 on the Fig. 1.; Fig. 4). Red and gray marly limestones of the *malmica* Zone contain frequent aptychi *Lamellaptychus beyrichi beyrichi* (Oppel) and *Punctaptychus punctatus punctatus* (Voltz), microcrinoids (*Saccocoma* sp.), other microplankton as *Parastomiosphaera malmica* (Borza), *Colomisphaera minutissima* (Colom), *C. pulla* (Borza), *C. carpathica* (Borza), etc., cf. Borza et al. 1982. The higher part of marly limestone complex contains Middle Tithonian species *Obtumodella bonetti* Doben. The appearing of *Praetintinnopsella* sp. characterizes the basal Upper Tithonian green gray marly limestones, while the higher association, containing *Crassicollaria intermedia* (Durand Delga), *C. brevis* Remane, *Calpionella alpina* Lorenz, *Colomisphaera minutissima* (Colom), etc. (cf. Fig. 4), indicates the Upper Tithonian.

3.2 BERRIASIAN

Both the uppermost part of the gray marly limestone complex and above-lying thick layered gray "biancône-type" limestones belong to the Upper Tithonian/Berriasian according to the microfossil content *Crassicollaria parvula* Remani, *Calpionella alpina* Lorenz, *C. elliptica* Cadisch, *Tintinnopsella carpathica* (Murgeanu & Filipescu), *T. longa* (Colom), *Remaniella cadischiana* (Colom), *Colomisphaera minutissima* (Colom) and *Nannoconus* aff. *steinmanni* Kamptner). Neither microfaunal, nor the macrofaunal content, similarly poor as in the Upper Jurassic deposits, allowed exact delimitation of the Tithonian/Berriasian boundary in the stu-

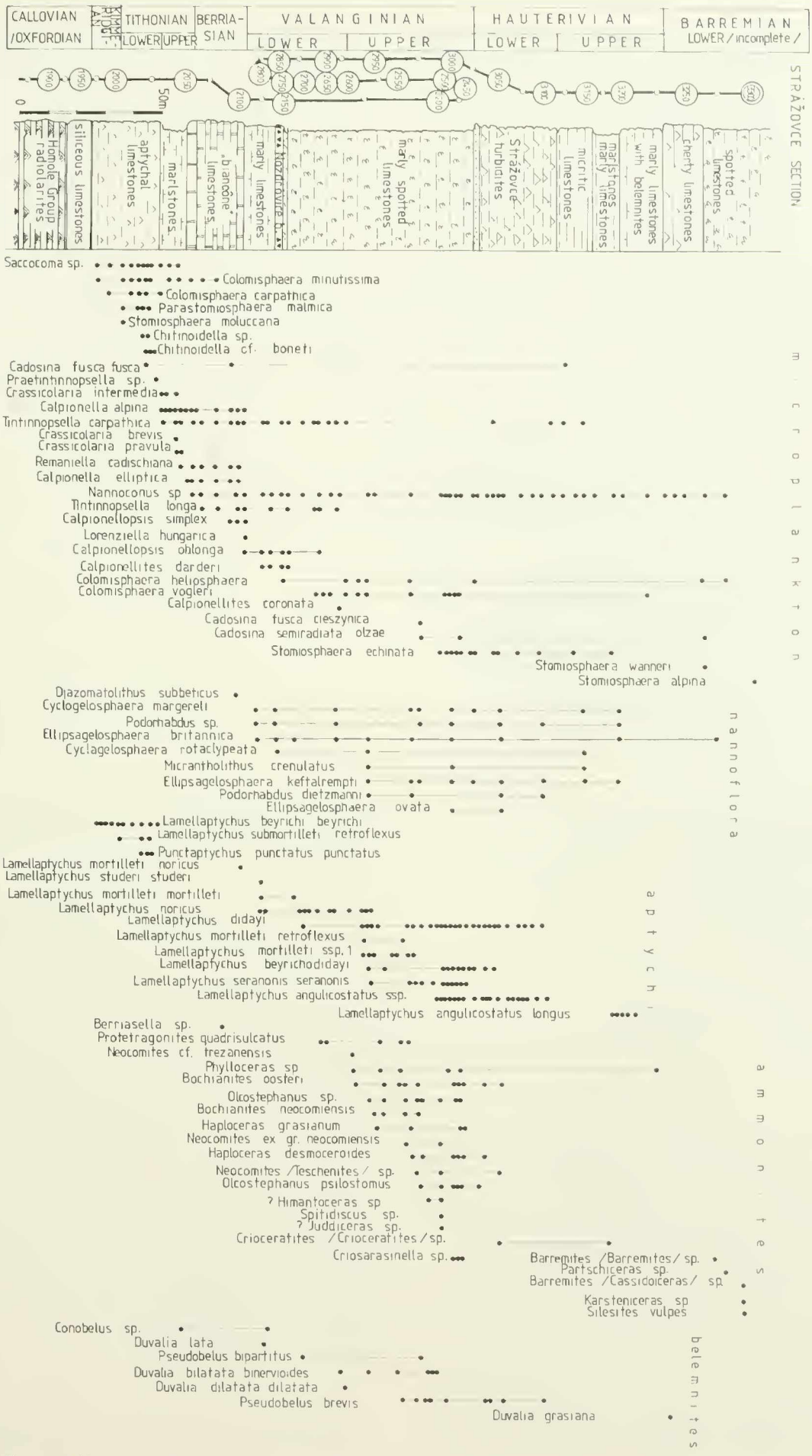

Fig. 4. Lithostratigraphic correlation and distribution of organic remains in the Strážovce-section (cf. loc. 8, Fig. 1).

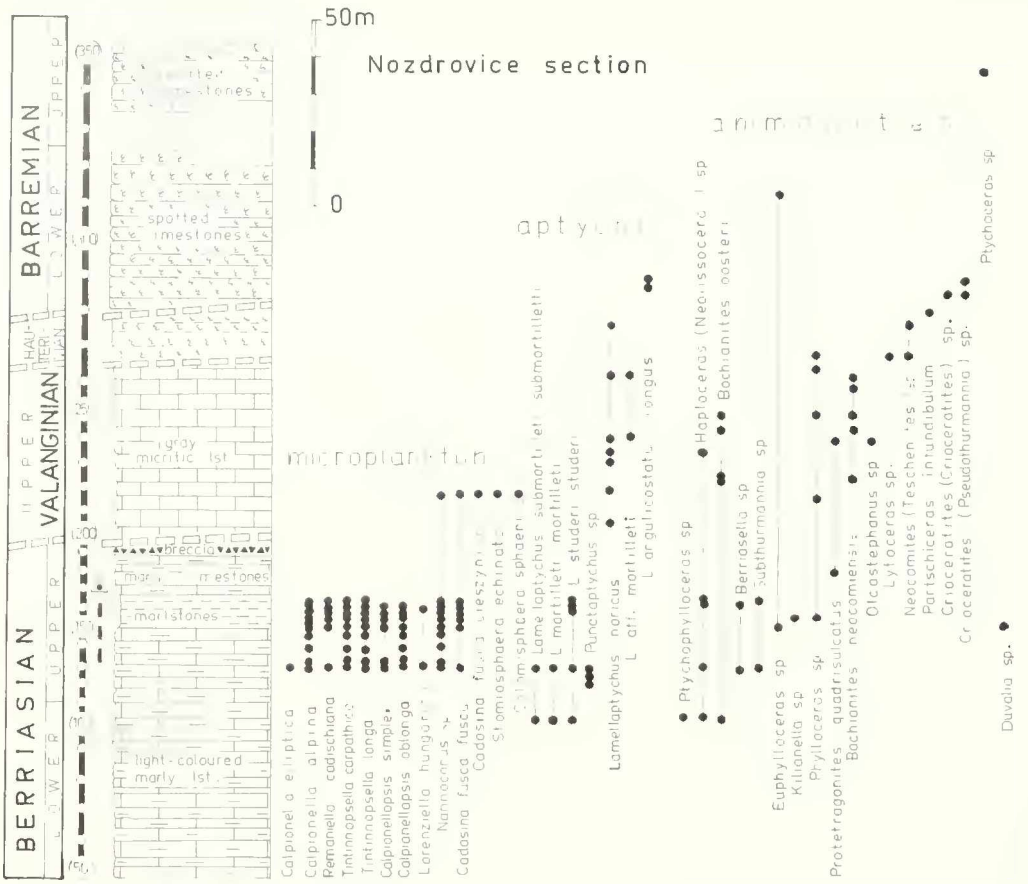

Fig. 5. Lithostratigraphical correlation and distribution of the main fossils in the Nozdrovice-section (loc. 1, Fig. 1).

died sections. The ammonites occur sporadically, being represented by mostly indeterminable fragments in Strážovce and Nordrovice section (loci 1 and 8 in Fig. 1; Figs. 4 and 5). Infrequent aptychi are usually small [*Lamellaptychus studeri studeri* (Ooster), *L. mortilleti mortilleti* (Pictet & Loriol), *L. mortilleti noricus* Trauth etc.].

The "biancône limestones" are characteristic lithostratigraphical unit, Upper Tithonian to Upper Berriasian in age. They represent a typical product of the pelagic bathyal environment, being characterized by facial uniformity, abundance of nanno- and microplanktic remains, but by scarcity of the macrofossils (among them dispersed aptychi dominate).

The Upper Berriasian *Calpionellopsis* Zone could be proved in several sections, being represented by the upper "Biancône" (loc. 8), by yellowish light-gray (marly) limestones (loc. 1), or by light-gray spotted limestones (loc. 3). The microfossil association in all the sections is nearly identical, but quantitative representation of individual taxa moderately changes (cf. Figs. 4, 5, 6).

3.3 VALANGINIAN

The lower part of the above-lying marly spotted limestone complex in several sections (loci 1, 8, 9) contains "Nozdrovice Breccia Horizon", consisting of irregular angular limestone clasts, mostly Upper Tithonian/Berriasian *(Calpionella* zone), but also older *(Crassicollaria* Z.) and younger *(Calpionellites* Z.) in age. The origin of the Nozdrovice Breccia could has been connected with probable Valanginian sedimentary gap in the northernmore Manín unit (influence of the Late Kimmerian tectonic deformations).

The Valanginian sediments contain a rich spectrum of microplanktic remains *(Calpionellites darderi* [Colom], *C. coronata* Trejo, *C. caravacaensis* Allemann, *Calpionella alpina* Lorenz, *Calpionellopsis oblonga* [Cadisch], *Tintinnopsella carpathica* [Murgeanu & Filipescu], *T. longa* [Colom], *Lorenziella hungarica* Knauer & Nagy, *L.* cf. *plicata* Remane, *Colomisphaera heliosphaera* [Vogler], *C. vogleri* [Borza], *Stomiosphaera echinata* Nowak, *Cadosina fusca cieszynica* Nowak etc.). However, the recent microbiostratigraphical knowledge do not allow to divide the Valanginian sequence more in detail.

Our macrofaunal findings enabled us to recognize the uppermost Lower Valanginian in the Butkov section (Fig. 7, probable equivalent with upper part of the French *Busnardoites campylotoxus* Zone), containing ammonite fragments, resembling *Kilianella pexiptycha* (Uhlig) and *Busnardoites* Nikolov, aptychi *Lamellaptychus aplanatus aplanatus* (Gillieron), *L. aplanatus retroflexus* Trauth, *L. mortilleti mortilleti* (Pictet & Loriol).

Zonal ammonites lack also in the Lower Upper Valanginian *Saynoceras verrucosum* Zone). However, several localities yielded ammonite remains, similar to *Neocomites neocomiensis* (d'Orbigny), *N. teschenensis* (Uhlig) and *Bochianites*

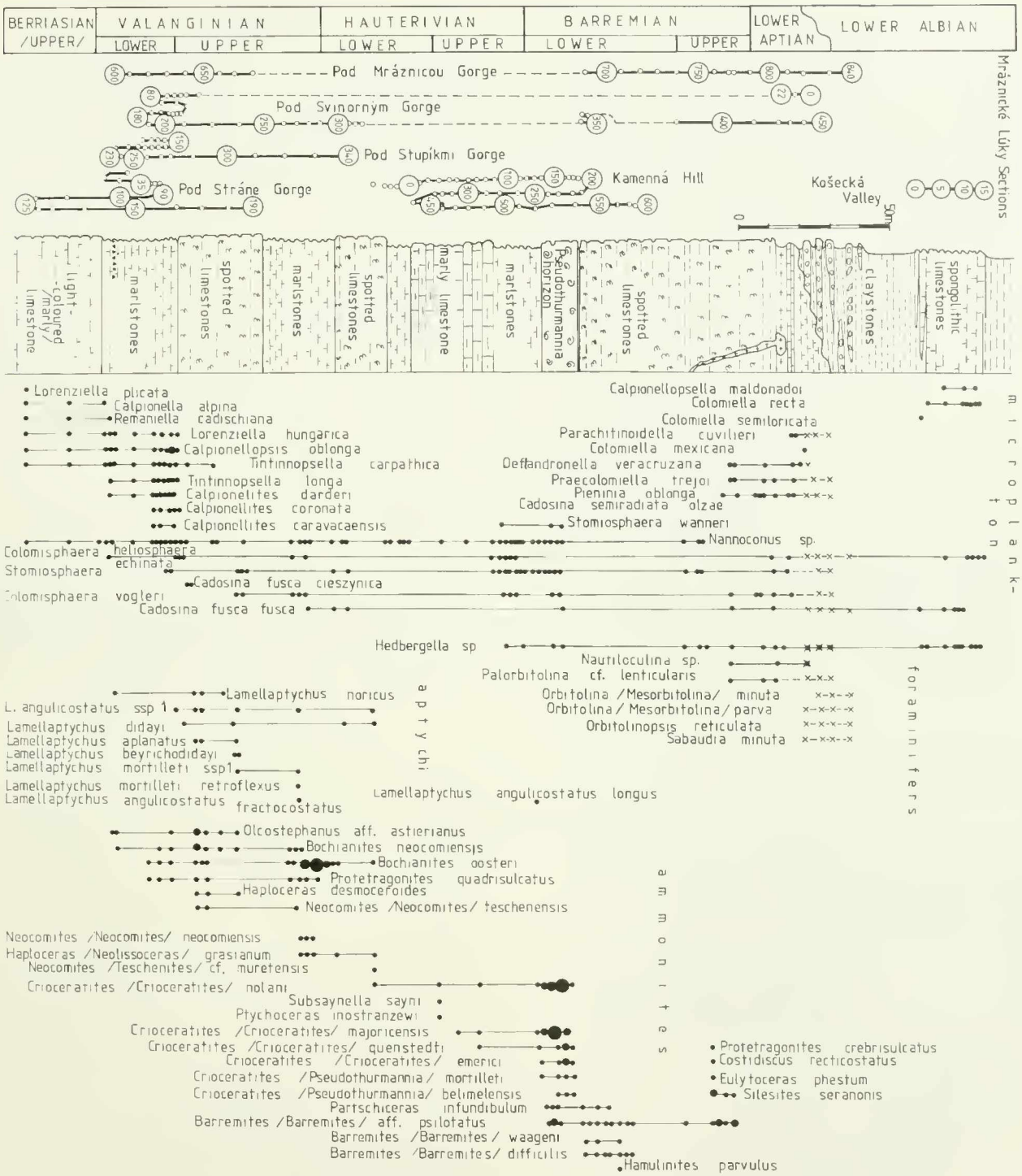

Fig. 6. Lithostratigraphical correlation of Mráznické lúky-sections and distribution of the main fossils (loci 2–6, Fig. 1).

oosteri Sarasin & Schöndelmayer, *B. neocomiensis* d'Orbigny, co-occuring with primitive aptychi *L. noricus* (Winkler), *L. aplanatus* (Gillieron), *L.* ex gr. *mortilleti*. The latter forms differ from the typical subspecies *L. m. mortilleti* (Pictet & Loriol) by more complicated course of ribs and we ascribe them to *L. mortilleti retroflexus* Trauth and to *L. mortilleti* ssp. (Fig. 6).

Spotted limestone complex of the Strážovce section (8), we earlier considered to be Lower Hauterivian in age, relying on findings of the first crioceratiform ammonites in its close overlie (Michalík & Vašíček 1979, Borza et al. 1980), belongs evidently also to the lower Upper Valanginian.

The horizon with the last primitive aptychi, is covered by layers probably equivalent to the *Himantoceras trinodosum* Zone with arcuate bended fragments *?Himantoceras* Thieuloy and with incomplete free-coiled shells, ribbed similarly to the Upper Hauterivian *Aegocrioceras* Spath, or to Upper Valanginian *Juddiceras* Spath (however, both the genuses were described from the Boreal realm until only). The sole well determinable specimen of *Himantoceras acuticostatum* Thieu-

LOY comes from a little outcrop near Zemianska Závada (SSE from Považská Bystrica, cf. Fig. 1).

The aptychi, found in this level, are represented exclusively by forms with backward to the umbo bounded ribs. Further free-coiled ammonite types with ribs bifurcated on the circle of ephebic coils appear in overlying horizons (Strážovce section, loc. 8, Fig. 1; Fig. 4). According to the Butkov-material (loc. 9, Fig. 1; Fig. 7) they are identical with *Criosarasinella heterocostata* (MANDOV) (sensu J.-P. THIEULOY 1977). This species occurs in the *Teschenites callidiscus* Zone of lower Uppermost Valanginian. Interestingly, neither this zonal species known from the Silesic unit of Outer West Carpathians, nor other *Teschenites* have been found in this horizon in the Strážovské vrchy Mts. Scarce belemnites *Pseudobelus brevis* PAQUIER, *Duvalia dilatata* (BLAINVILLE), *D. binervia* (RASPAIL) and *Hibolites cigaretus* STOYANOVA-VERGILOVA accompany this fauna.

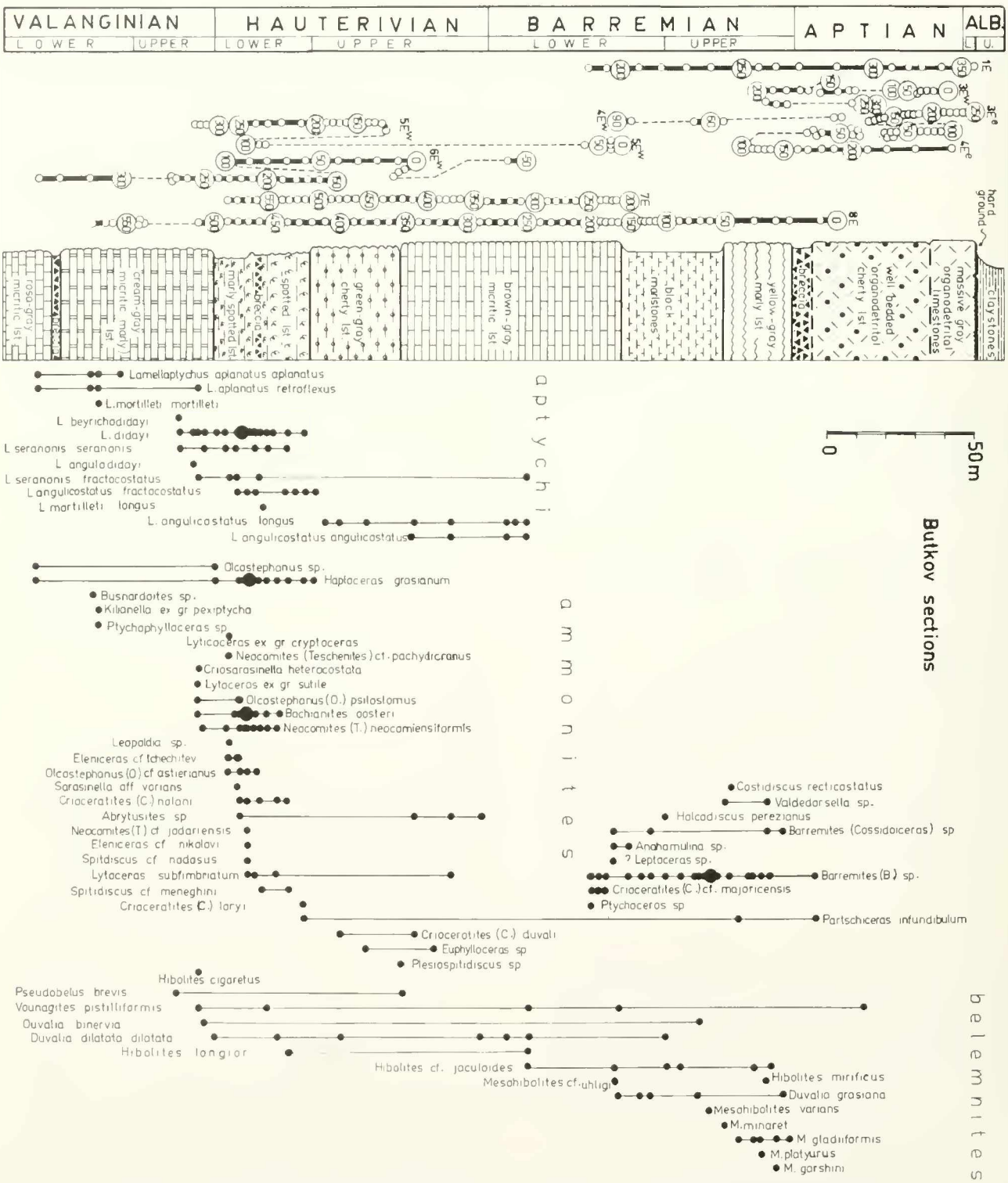

Fig. 7. Lithostratigraphical correlation of the section, incovered in the individual Butkov quarry-floors and fossil distribution in the incovered sequence (loc. 9, Fig. 1).

3.4 HAUTERIVIAN

The Valanginian/Hauterivian boundary cannot be exactly delimited neither on the base of microfossils, nor by macrofauna. We consider the micritic nannocone limestones with abundant *Teschenites neocomiensiformis* (Uhlig), *T.* cf. *jodariensis* (Douville), *T.* cf. *pachydicranus* Thieuloy, *Spitidiscus meneghinii* (Zigno), *Eleniceras* cf. *tchechitevi* Breskovski etc., with microplankton like *Nannoconus steinmanni* Kamptner, *N. colomi* (de Lapparent), *N. globulus* Brönimann, *N. kamptneri* Brönimann, less frequently with *Globochaete alpina* Lombard, *Cadosina fusca fusca* Wanner, *C.* cf. *cieszynica* Nowak, *C. semiradiata olzae* Nowak, *Colomisphaera heliosphaera* (Vogler), *C. vogleri* (), *Stomiosphaera echinata* Nowak, *S. wanneri* , *Gemeridella minuta* & Mišík, *Didemnoides moreti* (Durand Delga), *Didemnum carpaticum* Mišík & , rarely with *Tininnopsella carpathica* (Murgeanu & Filipescu) and with the foraminifers (*Spirillina* sp., *Patellina* sp., *Lenticulina* sp., *Heterohelix* sp.) belonging to the Lower Hauterivian.

An expressive complex of rhythmically bedded organodetrital, cherty and marly limestones with marly intercalations (Strážovce Formation) characterizes the deeper basinal slope (Strážovce section, loc. 8 in the Fig. 1, or Fig. 4). The base of each rhythm consists of detritic, gradationally bedded horizons with frequent clasts. Organic remains are fragmentary, often reworked. They frequently belong to shallow-marine organisms (gastropods, solenoporid algae, bryozoans etc.). The formation originated in turbiditic sedimentary regime.

Thin turbidites have been found in Butkov Lower Hauterivian sequence. However, a horizon of carbonate breccia, analogical to the Valanginian Nozdrovice Breccia occurs here, too. The first representatives of *Crioceratites* (*C. nolani* Kilian, somewhat higher *C. loryi* Sarkar) and *Abrytusites* sp. appear above the horizon with the last *Teschenites* (*Fig. 7*).

The uppermost Lower Hauterivian (both the French *Olcostephanus jeannoti* and *Lyticoceras nodosoplicatus* Zones) is not faunistically proved by us. However, according to several authors (Trauth 1938, Stefanov 1961, Gąsiorowski 1962) the occurrences of frequent aptychus *L. didayi* (Coquand) terminates just at the end of the Lower Hauterivian. Therefore, we used this criterium by delimitation of the Lower/Upper Hauterivian boundary in both the Strážovce- and Butkov sections.

The overlying deposits of such delimited Lower Hauterivian contain aptychi with angularly broken ribs like *L. angulicostatus* (Pictet & Loriol), similar to the typical subspecies, or to *L. angulicostatus longus* Trauth. Moreover, *Crioceratites duvali* Léveille and *Euptychoceras* sp. co-occur with this aptychi in the Butkov section, and sole specimen of *Subsaynella sayni* (Paquier) – the index ammonite of the French basal Upper Hauterivian according to Thieuloy (1973) have been found in an equivalent level of the Kamenná section (loc. 2, Fig. 1).

The uppermost Hauterivian *Plesiospitidiscus ligatus* Zone has not been safely macrofaunistically documented.

3.5 BARREMIAN

The macrofaunistically richest complex of the Carpathian Lower Cretaceous, the *Pseudothurmannia* Horizon appears in several sections (loci 1, 2, etc., cf. Adamíková et al., in press), above the deposits of Hauterivian s. str. It consists of 6–10 m thick complex of brown-gray micritic limestones with rich cephalopod fauna. The main part of microfossils belongs to nannocones, along with them more sporadically occur *Stomiosphaera alpina* Leischner, *Cadosina semiradiata olzae* Nowak, *Colomisphaera vogleri* (Borza), *Globochaete alpina* Lombard, calcified radiolarians, ostracods and foraminifers (*"Hedbergella"* sp., *Spirillina* sp., *Patellina* sp., *Lenticulina* sp., *Frondicularia* sp., *Heterohelix* sp.) and many others. *Crioceratites* s. str. prevail over infrequent *Pseudothurmannia* in the ammonite fauna. Last lamellaptychi with angularly broken ribs co-occur with these ammonites. In agreement with Lapeyre & Thomel (1974) and Adamíková et al. (in press) we consider this association to be Lower Barremian in age. However, the last occurrence of aptychi, closely connected with the underlying Hauterivian associations and the sudden disappearing of all the crioceratids above the *Pseudothurmannia* Horizon indicate a close connection of this horrizon with the Upper Hauterivian sequence.

The equivalent of the *Pseudothurmannia* Horizon behind the limits of its typical development can be recognized by monotonnous aptychi with angular ribs association and, probably also by appearing of *Hibolites jaculoides* Swinnerton-like belemnites.

The higher Lower Barremian horizons are in all the studied sections indicated by expressive deepening of the basin. The crioceratid fauna, inhabitor of relatively shallow bottom has been in short time span completely substitued by monotonnous barremitid ammonites – good swimmers, able to live in a free pelagic environment. The latter fauna occurs in black marlstones, micritic and spotted limestones with distal turbiditic structures. *Ellipsagelosphaera* dominates in the low-diversified nannoplankton associations, the microplankton consists of *Stomiosphaera wanneri* Borza, *S. alpina* Leischner, and of other forms (cf. Figs. 4, 5, 6), the foraminifers comprise frequent *Hedbergella* sp., *Spirillina* and *Lenticulina*. Lower part of the barremitid horizon yielded infrequent aberrant shells of *Hamulina lorioli* (Uhlig), *Hamulinites parvulus* (Uhlig), *Anahamulina* sp., *Karsteniceras* sp., more rarely spirally coiled *Pulchellia compressissima* (d'Orbigny), *Holcodiscus perezianus* (d'Orbigny), etc., solely also the belemnite *Mesohibolites* sp.

The zonal species *Silesites seranonis* (d'Orbigny) and *Costidiscus recticostatus* (d'Orbigny) occur in the Upper Barremian deposits, while *Mesohibolites* (*M. gladiiformis* Uhlig, *M. platyurus* Duval-Jouve, *M. minaret* Raspail and other) dominate in the belemnite fauna.

3.6 APTIAN

A complex of black-gray and gray detritic cherty limestones with characteristical breccia horizon on their base represents the products of Aptian sedimentation in the Butkov section (loc. 9 in the Fig. 1; Fig. 7). Gray silky marls with inter-

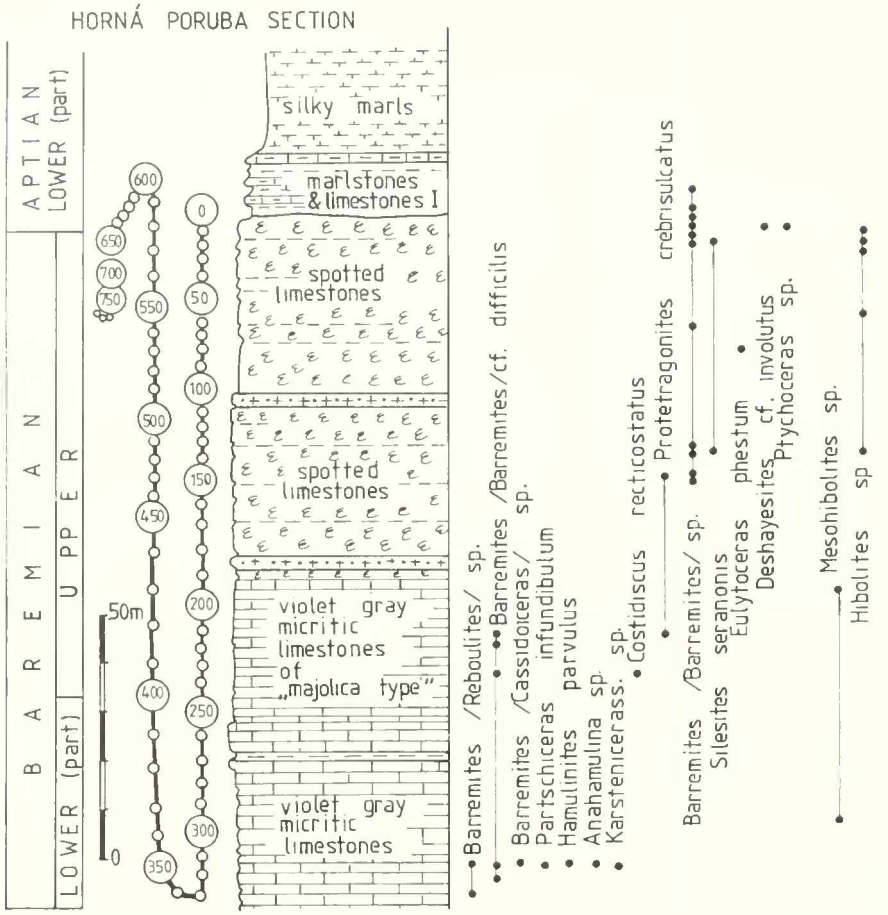

Fig. 8. Lithostratigraphic correlation and the distribution of main fossils in the Horná Poruba-section (loc. 7, Fig. 1).

calations of black-gray detritic limestone, lime breccias and paraconglomerates, tuffites and basic volcanics represent this level in other sections. They contain microfossils *Praecolomiella trejoi* Borza, *P. boneti* Borza, *Deflandronella veracruzana* (Trejo), *Parachitinoidella* cf. *cuvillieri* Trejo etc., foraminifers (*Hedbergella* sp., *Sabaudia minuta* [Hofker], *Nautiloculina* sp., *Palorbitolina* cf. *lenticularis* [Blumenbach], etc.). The Aptian macrofauna has been found in sole horizons of Horná Poruba section (Fig. 8), being represented by incomplete specimen, similar to *Deshayesites involutus* Spath.

Fragments of bivalve shells, crinoids, solenoporids, serpulids and orbitolinid foraminifers in the biopelsparitic and biointrasparitic limestones in higher part of the Butkov detritic complex (Fig. 7) and in the conglomerate horizons in other localities indicate Upper Aptian age (cf. Fig. 6).

3.7 LOWER ALBIAN

The uppermost horizon in the Butkov detrital complex consisting of light-gray micritic limestones contains a rich microfossil assemblage (*Colomiella recta* Bonet, *C. mexicana* Bonet, *Pieninia oblonga* Borza & Mišík etc.) and foraminifers *Sabaudia minuta* (Hofker), *Orbitolina texana* (Roemer) and others, indicating its Lower Albian age. Hard ground with borings of benthic organisms is developed on the surface of this horizon, covered by Upper Albian shally complex.

The complex of spongolithic micrital limestones near the base of Albian shales in Mráznické lúky region (loci 2–6) and Horná Poruba (loc. 7) with *Calpionellopsella maldonadoi* Trejo & *Colomiella recta* Bonet represents the last episode of carbonate sedimentation in the studied area. The environment of carbonate sedimentation definitively turned into a flysch basin, controlled by an active tectonic pulse of folded orogen.

4. SUMMARY

Development of the Lower Cretaceous Krížna-basin has been more complicated than usually treated. Remarkable occurrence of Lower Valanginian Nozdrovice Breccia indicate an effect of Late Kimmerian deformation of external zones. The clastic and turbiditic horizons, incorporated in Hauterivian, Barremian and Aptian sequences, indicate an increasing tectonic pulse, a symptom of Austrian orogenic phase, culminating during Albian/Cenomanian.

The combination of several parastratigraphical schemes, based on several organic groups (ammonites, aptychi, belemnites, micro- and nannoplankton) gets over the gaps in the recent biostratigraphical division of the Jurassic-Lower Cretaceous deposits of Krížna nappe. Particularly expressive advance has been achieved in the division of Valanginian and Hauterivian sequences (Tab. 1).

Table 1

		AMMONITES	APTYCHI	BELEMNITES
APTIAN		*Deshayesites* ex gr. *involutus* Spath		
BARREMIAN	UPPER	*Silesites seranonis* (d'Orbigny) *Barremites* sp. *Costidiscus recticostatus* (d'Orbigny)		*Mesohibolites gladiiformis* (Uhlig) *Hibolites mirificus* Stoyanova-Vergilova *Mesohibolites platyurus* (Duval-Jouve) *Mesohibolites minaret* (Raspail)
	LOWER	*Barremites* (B.) ex gr. *difficilis* (d'Orbigny) *Hamulina lorioli* Uhlig *Hamulinites parvulus* (Uhlig) *Pulchellia compressissima* (d'Orbigny) *Crioceratites* (C.) *majoricensis* (Nolan) *Crioceratites* (C.) *emerici* Léveillé *Pseudothurmannia mortilleti* (Pictet & Loriol)	*Lamellaptychus angulicostatus longus* Trauth	*Duvalia binervia* (Raspail) *Duvalia grasiana* (Duval-Jouve) *Hibolites longior* Schwetzoff *Hibolites* cf. *jaculoides* Swinnerton
HAUTERIVIAN	UPPER	*Crioceratites* (C.) *duvali* Léveillé *Subsaynella* cf. *sayni* (Paquier)	*L. angulicostatus angulicostatus* (Pictet & Loriol)	*Duvalia dilatata dilatata* (Blainville)
	LOWER	*Crioceratites* (C.) *loryi* (Sarkar) *Crioceratites* (C.) *nolani* (Kilian) *Abrytusites* sp. *Eleniceras tchechitevi* Breskowski *Neocomites (Teschenites)* cf. *jodariensis* (Douvillé) *Spitidiscus* cf. *meneghinii* (Zigno) *Neocomites (Teschenites) neocomiensiformis* (Uhlig)	*L. didayi* (Coquand) *L. angulicostatus fractocostatus* Trauth	*Pseudobelus brevis* Paquier
VALANGINIAN	UPPER	*Criosarasinella heterocostata* (Mandov) *Himantoceras* sp., *Juddiceras* sp. *Bochianites neocomiensis* d'Orbigny *Neocomites* (N.) *neocomiensis* (d'Orbigny) *Neocomites* (N.) *teschenensis* (Uhlig)	*L. seranonis* (Coquand) *L.* aff. *mortilleti* *L. mortilleti* ssp. 1. *L. mortilleti retroflexus* Trauth	*Hibolites cigaretus* Stoyanova-Vergilova *Duvalia dilatata* (Blainville)
	LOWER	*Kilianella* ex gr. *pexiptycha* (Uhlig) *Busnardoites* sp.	*L. aplanatus retroflexus* Trauth *L. aplanatus aplanatus* Gilliéron	
			L. noricus (Winkler)	
BERRIASIAN TITHONIAN			*L. mortilleti mortilleti* (Pictet & Loriol) *L. mortilleti noricus* Trauth *L. studeri studeri* (Ooster) *L. beyrichi beyrichi* (Oppel) *Punctaptychus punctatus punctatus* (Voltz)	*Duvalia lata* (Blainville)

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Plate 1

Fig. 1. *Kilianella* ex gr. *pexiptycha* UHLIG, ×1. Specimen BK 8–565/7. Butkov quarry, 8. floor, upper Lower Valanginian.

Fig. 2. *Himantoceras* sp., ×2. Spec. ZC–2522. Strážovke section, 2522 m, Upper Valanginian.

Fig. 3. *Juddiceras* sp., ×1. Spec. ZC 2995/8, Strážovce section, 2995 m, Upper Valanginian.

Fig. 4. *Himantoceras acuticostatum* THIEULOY, ×1. Spec. ZZ–5/1. Zemianska Závada. Upper Valanginian.

Fig. 5. *Criosarasinella heterocostata* MANDOV, ×1. Spec. BK 8–510/2. Butkov quarry, 8. floor, uppermost Valanginian.

Fig. 6. *Crioceratites (Crioceratites) nolani* KILIAN, ×1. Spec. BK 8–440. Butkov-quarry, 8. floor, Lower Hauterivian.

Fig. 7. *Neocomites (Teschenites)* cf. *jodariensis* DOUVILLE, ×1. Spec. BK 8–470/16. Butkov-quarry, 8. floor, Lower Hauterivian.

Fig. 8. *Spitidiscus* cf. *meneghini* ZIGNO, ×1. Spec. BK 6–80/2. Butkov quarry, 6. floor, Lower Hauterivian.

Fig. 9. *Crioceratites (Crioceratites) duvali* LÉVEILLE, ×1. Spec. BK 8–400/2. Butkov quarry, 8. floor, Upper Hauterivian.

Fig. 10. *Pulchellia compressissima* D'ORBIGNY, × 1. Spec. BK 8–170/9. Butkov quarry, 8. floor, Lower Barremian.

Fig. 11. *Hamulina lorioli* UHLIG, ×1. Spec. PL 1–4/7. Polomec, Zabukovinské quarry near Lietavská Lúčka, Lower Barremian.

Fig. 12. *Deshayesites* ex gr. *involutus* SPATH, ×1,5. Spec. HP–580, Horná Poruba-section, Lower Aptian.

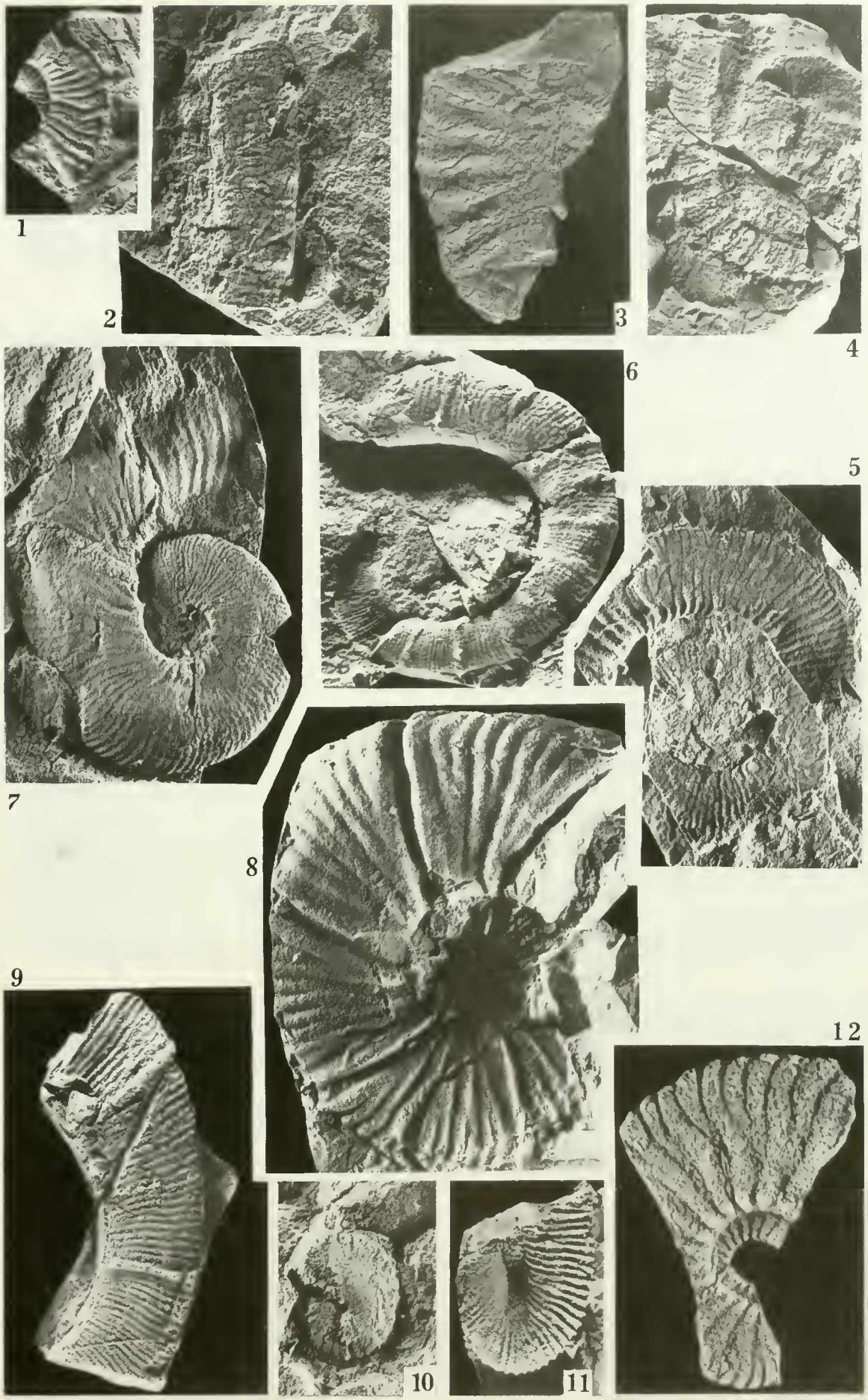

Plate 2

all magnifications 285×

Fig. 1. *Chitinoidella boneti* DOBEN, thin section 7587, Strážovce section, 2025 m, *Chitinoidella* Zone, Middle Tithonian.

Fig. 2. *Calpionella alpina* LORENZ, thin section No 7589. Strážovce section, 2060 m, *Calpionella* Zone, Tithonian/Berriasian.

Fig. 3. *Crassicollaria parvula* REMANE, thin section No 7588, Strážovce section 2050 m, *Calpionella* Zone, Tithonian/Berriasian.

Figs. 4–5. *Tintinnopsella carpathica* MURG. & FILIP., thin sections 7590, 7592, Strážovce section 2060, 2090 m, *Calpionella* Z., Tithonian/Berriasian.

Fig. 6. *Calpionellopsis simplex* COLOM, thin section No 7593, Strážovce section 2100 m, *Calpionellopsis* Z., Berriasian/Valanginian.

Fig. 7. *C. oblonga* (CADISCH), thin section No 7594, Strážovce section 2110 m, *Calpionellopsis* Zone, Berriasian-Valanginian.

Fig. 8. *Remaniella cadischiana* (COLOM), thin section No 7593, Strážovce section 2100 m, *Calpionellopsis* Zone, Berriasian-Valanginian.

Fig. 9. *Tintinnopsella longa* (COLOM), thin section No 7681, Pod Svinorným Gorge-section, *Calpionellites* Zone, Berriasian-Valanginian.

Fig. 10. *Calpionellites darderi* (COLOM), thin section No 7596, Strážovce section 2140 m, *Calpionellites* Zone, Berriasian-Valanginian.

Fig. 11. *Praecolomiella trejoi* BORZA, thin section No 7710. Pod Mráznicou Gorge-section, *Praecolomiella* Zone, Aptian.

Fig. 12. *Deflandronella veracruzana* TREJO, thin section 7710, Pod Mráznicou G.-section, *Praecolomiella* Zone, Aptian.

Fig. 13. *Colomiella mexicana* BONET, t. s. No 47a/8, Butkov section, *Colomiella* Zone, Aptian-Albian.

Figs. 14–15. *Colomiella recta* BONET, t. s. No 47a/81, Butkov section, *Colomiella* Zone, Upper Aptian-Albian.

Fig. 16. *Colomisphaera minutissima* (COLOM), t. s. No 7587, Strážovce section 2045 m, *Calpionella* Zone, Tithonian/Berrasian.

Figs. 17–18. *Parastomiosphaera malmica* (BORZA), t. s. No 2005 (g), Strážovce section, 2005 m, Lower Tithonian.

Fig. 19. *Cadosina minuta* BORZA, t. s. No 7703, Pod Stráne Gorge-section, *Calpionellopsis* Zone, Berriasian/Valanginian.

Fig. 20. *Didemnum carpaticum* MIŠIK & BORZA, t. s. No 7652, Strážovce section 3270 m, Barremian.

Fig. 21. *Stomiosphaera echinata* NOWAK, t. s. No 7607, Strážovce section 2605 m, Valanginian.

Fig. 22. *Colomisphaera vogleri* (BORZA), t. s. No 8E–320/81, Butkov quarry, 8. floor, 320 m, Hauterivian.

Fig. 23. *Colomisphaera heliosphaera* (VOGLER), t. s. 8E–290/81, Butkov quarry, 8. floor, 290 m, Hauterivian.

Fig. 24. *Cadosina fusca cieszynica* NOWAK, t. s. No 8E–5/81, Butkov quarry, 8. floor, 5 m, Aptian.

Fig. 25. *Cadosina semiradiata olzae* NOWAK, t. s. 8E–5/81, Butkov quarry, 8. floor, 5 m, Aptian cherty limestones.