GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 34, 5, BRATISLAVA, OCTOBER 1983,
Pp. 591—615

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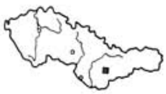
COMPOSITION AND ECOLOGY OF THE "PSEUDOTHURMANNIA-FAUNA", LOWER BARREMIAN OF THE KRÍŽNA-NAPPE IN THE STRÁŽOVSKÉ VRCHY MTS.

(Figs. 7, Pls. 2, Tabs. 4)



Abstract: A stratigraphically homogeneous fossiliferous Pseudothurmannia-bed with rich occurrence of crioceratid ammonites has been ascertained on several Lower Cretaceous localities of Krížna-nappe in Strážovské vrchy Mts. This fossiliferous niveau can be used as a reliable bio- and lithostratigraphical "marker-horizon" in the monotonous "Neocomian" limestone and marlstone sequence with poor fossil content. Kimoto's similarity index together with other aspects of correlation prove stratigraphic and paleogeographic homogenity of compared localities, hitherto placed into different tectonic units.

Резюме: В последовательности нижнемеловых осадков крижнянского покрова Стражовских гор был в нескольких месторождениях обнаружен стратиграфически гомогенный горизонт с богатым появлением криоцератных аммонитов. Этот уровень содержащий окаменелости представляет достоверный био- и литостратиграфический „маркирующий горизонт" в толще пластов известняков и мергелей „неокомской фации" относительно бедной окаменелостями. Кимотов индекс сходства и другие аспекты корреляции доказывают стратиграфическо-палеографическое единство сравниваемых местонахождений включаемых до ныне в разные тектонические единицы.

Introduction

Althougt the first paleontological papers dealing with Lower Cretaceous sequences of the Strážovské vrchy Mts. appeared in the last century (Stur, 1860, Foetterle, 1864 etc.), their paleontological scrutiny has been rather poor. This situation did not change even in the first half of this century: paleontological data were only seldom dispersed in regional geological papers (Kulczár, 1917; Andrusov, 1932 etc.). More extensive investigations have begun after 1945 (Maheľ, 1946, 1948, 1961, 1962; Eristavi, 1961 etc.). Recently, more detailed studies of Lower Cretaceous stratigraphy and paleogeography in Krížna-nappe with special emphasis on ammonite-, aptychal-, belemnite-, tintinnid- and nannofloral stratigraphy and on sedimentologic-lithological analysis have been done by Michalík — Vašíček, 1979; Borza et al., 1980; Michalík et al., 1980; Vašíček — Michalík, 1981. The authors divided the investigated area, built of Zliechov-succession of Krížna-nappe (Maheľ, 1959) into southernmore, deeper Strážovce-

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and Valaská Belá-belts (Figs. 1, 2) and into relatively shallower zone of Nozdrovice-, Mráznica- and Lietava-belts. The zones were separated by another, transitional area of Stredná-, Horná Poruba- and Dolná Poruba-belts.

The aim of this study is the description of faunistical composition of individual localities, mutual correlation of the spectra obtained, and determination of stragraphic-paleogeographical similarity of localities studied, and degree of homogenity of supposed fossiliferous index-horizon on the base of both the facts and literary data collected.

Rich, relatively well preserved ammonite material, obtained during field investigations of Lower Cretaceous sequences in Strážovská vrchy Mts. during 1976—1981, allowed more detailed paleontological, biostratigraphical and paleoecological studies. However, only those localities with more than thirty reliable determined ammonite specimens could have been selected for statistical evaluation. Five localities were evaluated: Laz and Na piate (both on Polomec-hill near Lietavská Lúčka), Kamenná near Košeca, Solviná near Dolná Poruba, and Tarabová near Zemianska Závada (Fig. 1). Although the former four localities were usually ranged without any doubts to the Krížna-nappe, the last one has been considered to be a part of Choč-nappe sequence (Rakús, 1975).

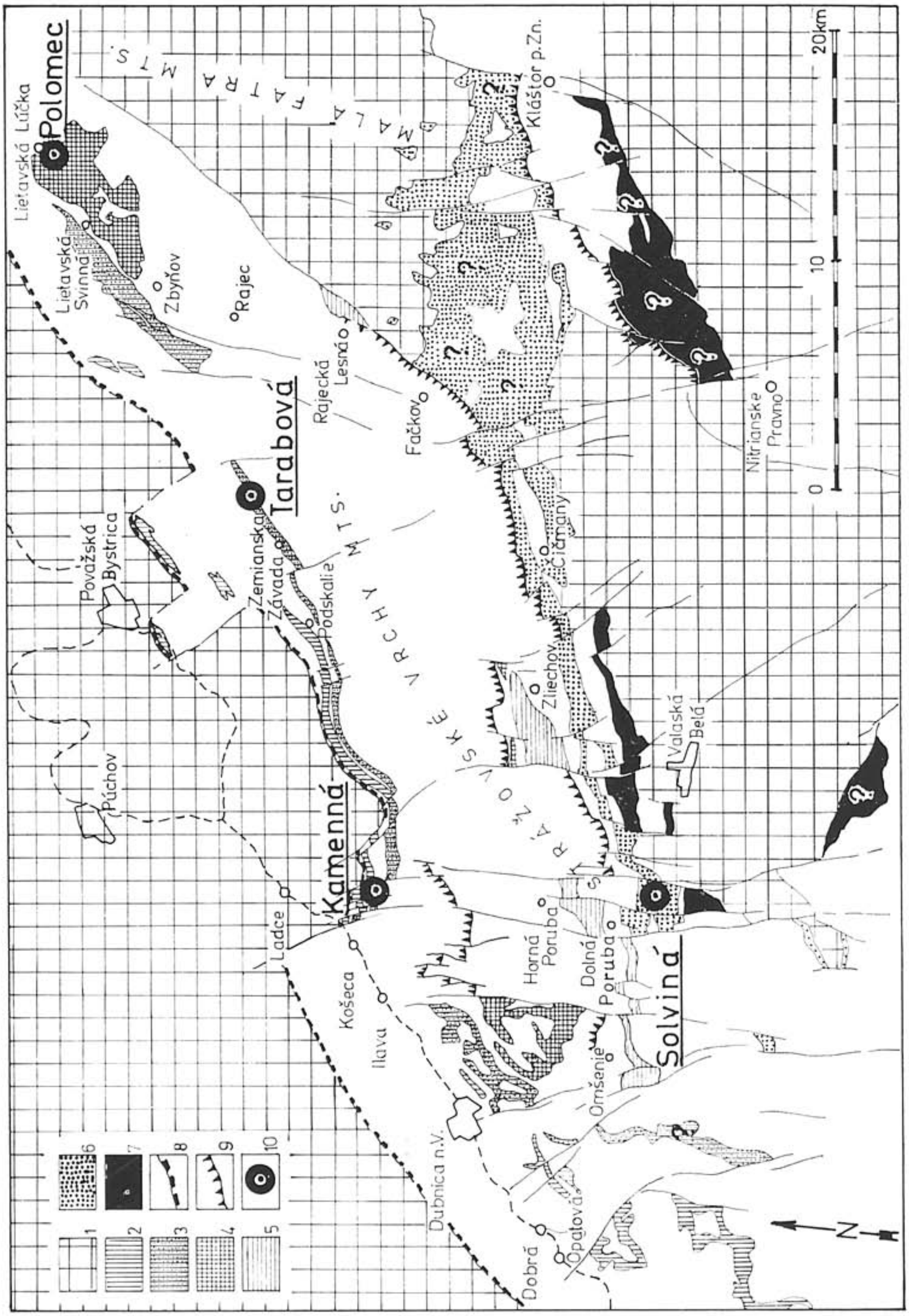
The former two localities (Laz and Na piate quarries, see Fig. 2) are uncovered by Považské cementárne-cement works on NE Polomec-hill slopes. The quarry walls uncover Hauteriv-Barremian carbonate sequence. Its lower members bear frequent slumping- and turbidite marks. Well uncovered Pseudothurmannia- bed is represented by light gray micritic, locally spotted limestone with reddish and greenish gray intercalations. Eight to nine meters thick beds contain rich fauna of crioceratids, aptychi and belemnites. It passes upwards into thick complex of light gray-brown marly limestones with Lower Barremian ammonites and brachiopods, higher up into Barremian spotted limestones covered by thin black marl layer. All

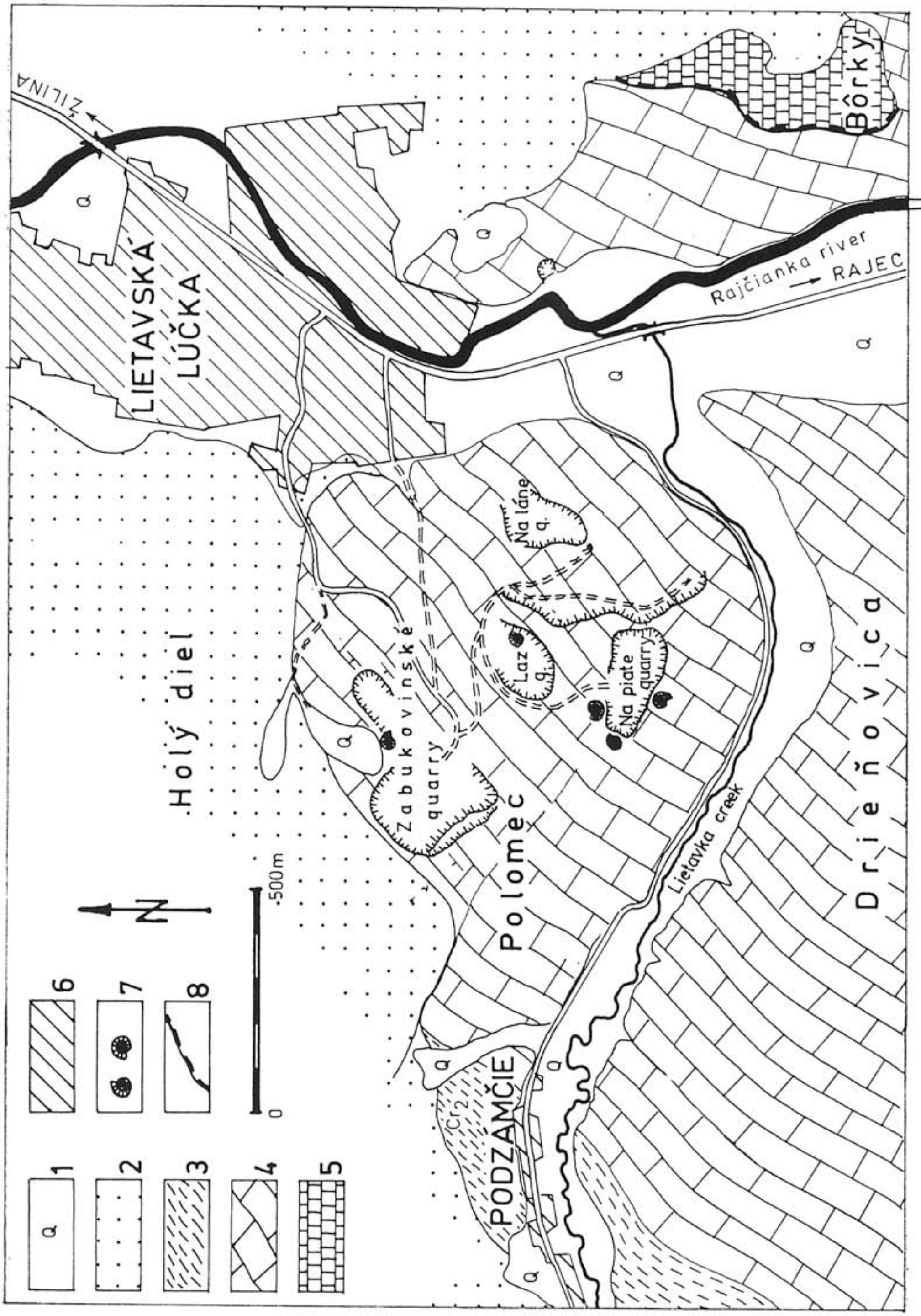
Fig. 1. Distribution of Lower Cretaceous complexes in the Krížna-nappe of Strážovské vrchy Mts., with denoting of localities investigated. Moderately schematized. *Symbols:* 1 - Prae-Cretaceous complexes and the tectonic substrate of the Krížna--nappe, 2—7: Lower Cretaceous outcrops of the structural belts defined in Michalík-Vašíček (1979); 2 - Nozdrovice belt, 3 - Mráznica belt, 4 - Lietava belt, 5 - Stredná valley belt, 6 - Strážovce belt, 7 - Valaská Belá belt, 8 - nappe front, 9 - back thrusts, 10 - investigated localities of the Pseudothurmannia-bed.

Fig. 2. A sketch of the geological situation of Lietavská Lúčka-area with denoting of Polomec-hill localities. *Symbols:* 1 - Quaternary cover, 2 - Paleogene sediments, 3—4 - Krížna-nappe: 3 - Albian claystones, 4 - Lower Cretaceous limestones, 5 - Triassic carbonates of the Choč-nappe, 6 - urbanized area, 7 - ammonite localities of the Pseudothurmania bed, 8 - charriage plane of the Choč-nappe.

Fig. 3. A sketch of the geological situation of Kamenná-hill near Košeca with denoting of Pseudothurmannia bed outcrops. *Symbols:* 1 - Albian claystones, 2 - Bar--remian spotted limestones, 3 - Pseudothurmannia bed, 4 - Upper Hauterivian marly limestones, 5 - faults (all in the Krížna-nappe).

Fig. 4. A sketch of the geological situation of Dolná Poruba — Valaská Belá area with denoting of Solviná- and Zrázy localities. *Symbols:* 1 - Belá-unit (substrate of the Krížna-unit s. s.), 2—10: Krížna-nappe (Zliechov-unit), 2 - Carpathian Keuper, 3 - Upper Rhaetian Fatra Fm., 4 - Hettangian Kopieniec Fm., 5 - Liassic limestones, 6 - Middle Jurassic complexes, 7 - Upper Jurassic sediments, 8 - Berriasian to Hauterivian limestone sequence, 9 - Barremian limestones, 10 - Aptian-Albian shales, 11 - Triassic carbonates of the Choč-nappe, 12 - Quaternary cover, 13 - urbanized area, 14 - roads and communications, 15 - ammonite localities of the Pseudothurmania bed, 16 - faults.


1
2
3
4
5
6
7
8
9
10
N
Polomec
Lietavská Lúčka
Lietavská Svinná
Zbyňov
Rajec
Rajecká Lesná
MALÁ FATRA MTS.
Kláštor p.Zn.
Fačkov
Tarabová
Zemianska Závada
Podskalie
Považská Bystrica
Púchov
STRÁŽOVSKÉ VRCHY MTS.
Čičmany
Zliechov
Valaská Belá
Nitrianske Pravno
Kamenná
Ladce
Košeca
Ilava
Horná Poruba
Dolná Poruba
Solviná
Omšenie
Dubnica n.V.
Opatová
Dobrá
0
10
20km



1
2
3
4
5
6
7
8
Q
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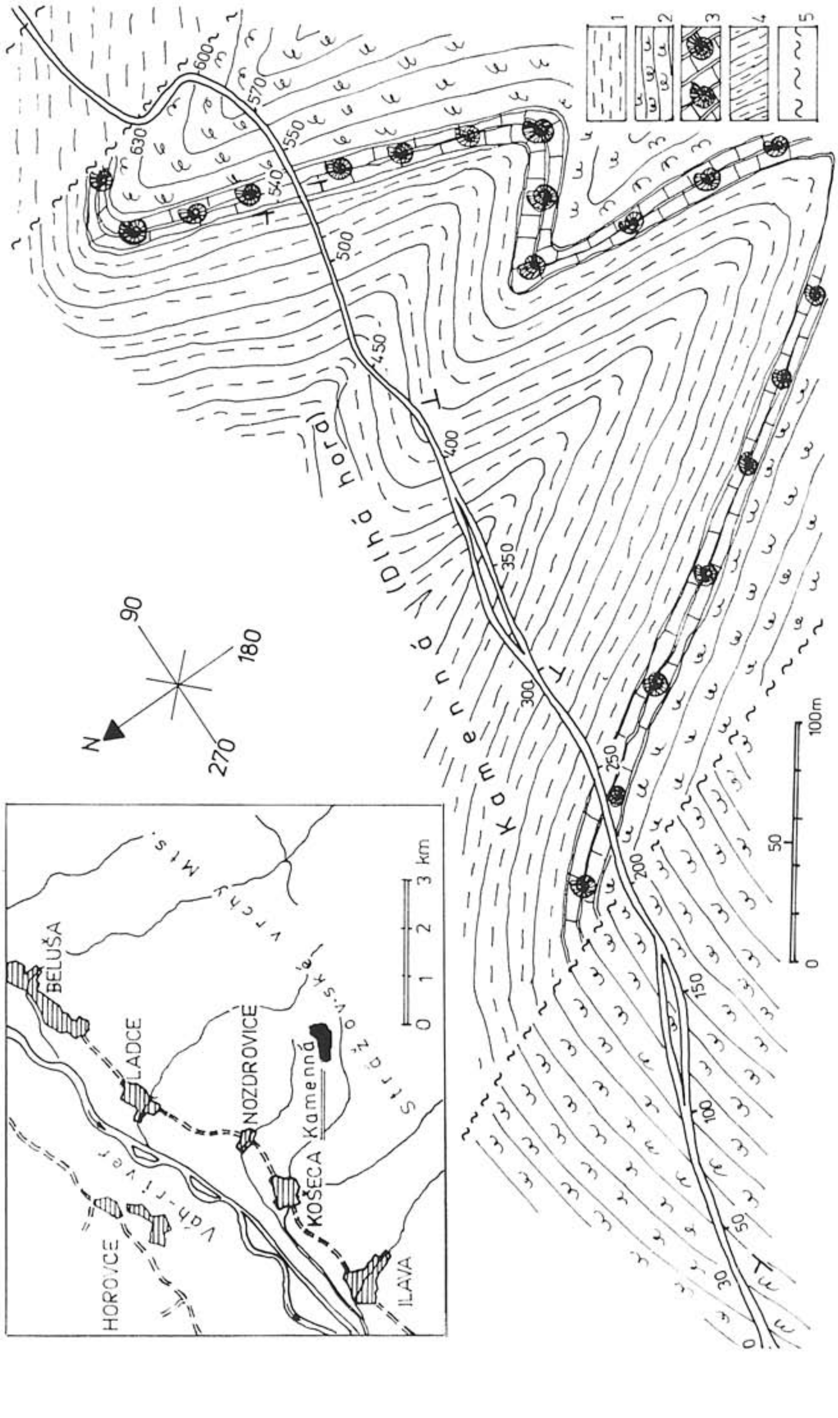
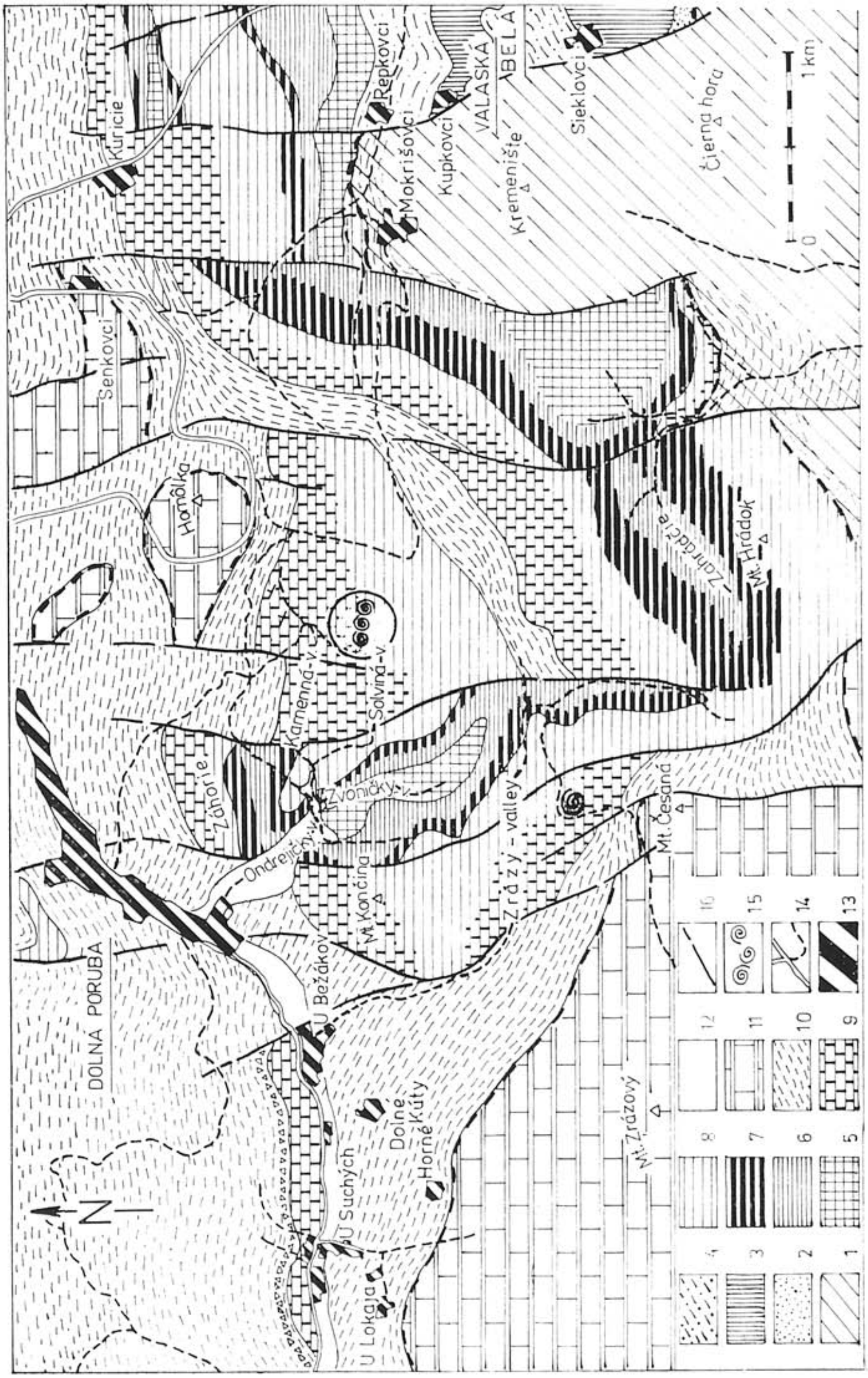
500 m
N
ŽILINA
LIETAVSKÁ LÚČKA
Holý diel
Bôrky
Rajčianka river
RAJEC
Zabukovinské quarry
Laz q.
Na láne q.
Na piate quarry
Polomec
Drieňovica
Lietavka creek
PODZÁMČIE
Cr2


Kamenná (Dlhá hora)
N
90
180
270
100m
BELUŠA
LADCE
NOZDROVICE
KOŠECA
ILAVA
HOROVCE
Váh-river
Kamenná
Strážovské vrchy Mts.
3 km


DOLNÁ PORUBA
VALASKÁ BELÁ
Kuricie
Senkovci
Repkovci
Mokrišovci
Kupkovci
Kremenište
Sieklovci
Čierna hora
0
1 km
Homôlka
Záhorie
Kamenná-v.
Solvína-v.
Zvoničky-v.
Ondrejičky-v.
Mt. Končina
Zrdzy - valley
Mt. Česaná
Zahradčie
Mt. Hrádok
U Bežákov
Dolné Kúty
Horné Kúty
U Suchých
U Lokaja
Mt. Zrázový
1
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16

the complexes are flat folded, the effect of deformation being more intensive on the eastern border of the area.

The Kamenná section is uncovered on broad flat hill ridge between Košecká- and Nozdrovická valleys (Fig. 3). Several inconsistent outcrops in the woody hill and also a shallow forest road-cut uncover both the lower, Upper Hauterivian complex of gray biomicritic nannocone limestones with several angularly disintegrating layers, and the highermore, Lower Barremian thick-bedded gray micritic spotted limestones. Pseudothurmannia-bed of characteristic lithology and faunal content is approximately 7—8 m thick. The complexes are slightly deformed and disturbed by several transversal faults.

The Solviná-locality is on a afforested hill between closures of both Kamenná- and Solviná valleys, SE of the village of Dolná Poruba (Fig. 4). The layers of brown-gray micritic limestone with slight marly admixture and characteristic ammonite assemblage (= Pseudothurmannia bed) dipp to the north, passing upwards into a thick sequence of thick-bedded gray spotted limestones.

The last, Tarabová locality is uncovered by escarpment of state road in SW foot of the Tarabová-hill NE of Zemianska Závada village. This section (Fig. 5) uncovers a strong tectonized sequence of gray spotted limestones with several more marly horizons. The Pseudothurmannia- bed crops out on its base. The contact with higher lying complex, consisting of Liassic crinoidal limestones, lenses of Rhaetian Norovica Limestone Fm. and Upper Triassic Hauptdolomite Group is covered by scree. This higher sequence evidently belongs to the Choč-nappe. Rakús (1975) considered also the previously decribed Lower Cretaceous sequence to be a normal continuation of Choč-nappe succession. However, everywhere in adjacent parts of Choč-nappe, the Lower Cretaceous sequence beginning with Tithonian-Berriasian Biancône-limestones pass upwards into more marly thin bedded limestones and finishes with Upper Valanginian-Lower Hauterivian flyschoidal marly complex.

Thus, the Pseudothurmannia bed consists of 6—10 m thick sequence of well-bedded brown-gray compact, more-or-less marly micritic limestone with a rich ammonite fauna (subgenera *Crioceratites* and *Pseudothurmannia* prevails), sole aptychi (*Lamellaptychus angulicostatus longus*) and belemnites The prevailing part of microfossils belongs to nannocones. Stomiosphaerids, cadosinids colomisphaerids, globochaetes, calcified radiolarians, ostracods and forams (*„Hedbergella“ sp., Spirillina sp.)* occurs less frequently. Surprisingly, *Tintinnopsella carpathica* (Murgeanu et Filipescu) sporadically occurs here, too (Borza et al., 1982).

Preservation of material and research methods used

The ammonites are mostly preserved as sculptural moulds, flat depressed into bedding planes, sometimes also deformed by lateral pressure. Their inner whorls are usually limonitized, or broken before burial. The sutures are usually not preserved.

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* Given geological interpretation of Tarabová-slopes is far from unambigous one. The Triassic-Jurassic „Rohatá skala“ -sequence of Choč nappe seems to continue from Domerian red-rose crinoidal limestones, through condensed Toarcian-lower Dogger Fe-Mn enriched horizon, upper, Dogger-Malm red cherty sparitic and nodular micritic limestones, to Tithonian-Berriasian rosa-gray „biancône“ limestones. Thus, there is little reason to put the thrust plane inside a complete Jurassic-Lower Cretaceous sequence, like the authors (remark of the reviewer).

In taxonomical evaluation, we measured morphological parameters currently used in the literature. We emphasized our attention on coiling pattern and development of sculpture during individual growth stages: the changes in this diagnostical marks are considered to be important taxonomical crioceratid criteria. The U (umbilicus width) and H (height) values, measured by various diameters (D) of each the shell have been used to calculation of U/D and H/D ratios. Measurements confirmed the coiling regularity by more tighly coiled shells (ratio deviations did not overstep the limits 0.01—0.08). The more expressive deviations, observed on free coiled shells, could have been caused by inequality in uncoiling of shell spire during growth (beside secondary deformation and impreciseness of the measurement). Curve slope statistical evaluation of shell coiling by individual species indicates rather high intraspecific variability of this parameter: the values of different crioceratid species mutually overlap.

Systematic descriptions

Systematic interpretation of the genus *Crioceratites* is based on suggestion of Wiedmann (1962), evaluation of species is supported by definitions of Immel (1978) at first.

Suborder *Ancyloceratina* Wiedmann, 1966
Family *Ancyloceratidae* Meek, 1876
Genus *Crioceratites* Léveillé, 1837
Subgenus *Crioceratites* Léveillé, 1837

Type-species: *Crioceratites duvali* (Léveillé, 1837), Hauterivian deposits of France.

Crioceratites (Crioceratites) majoricensis (Nolan, 1894)
Pl. 1., Fig. 1.

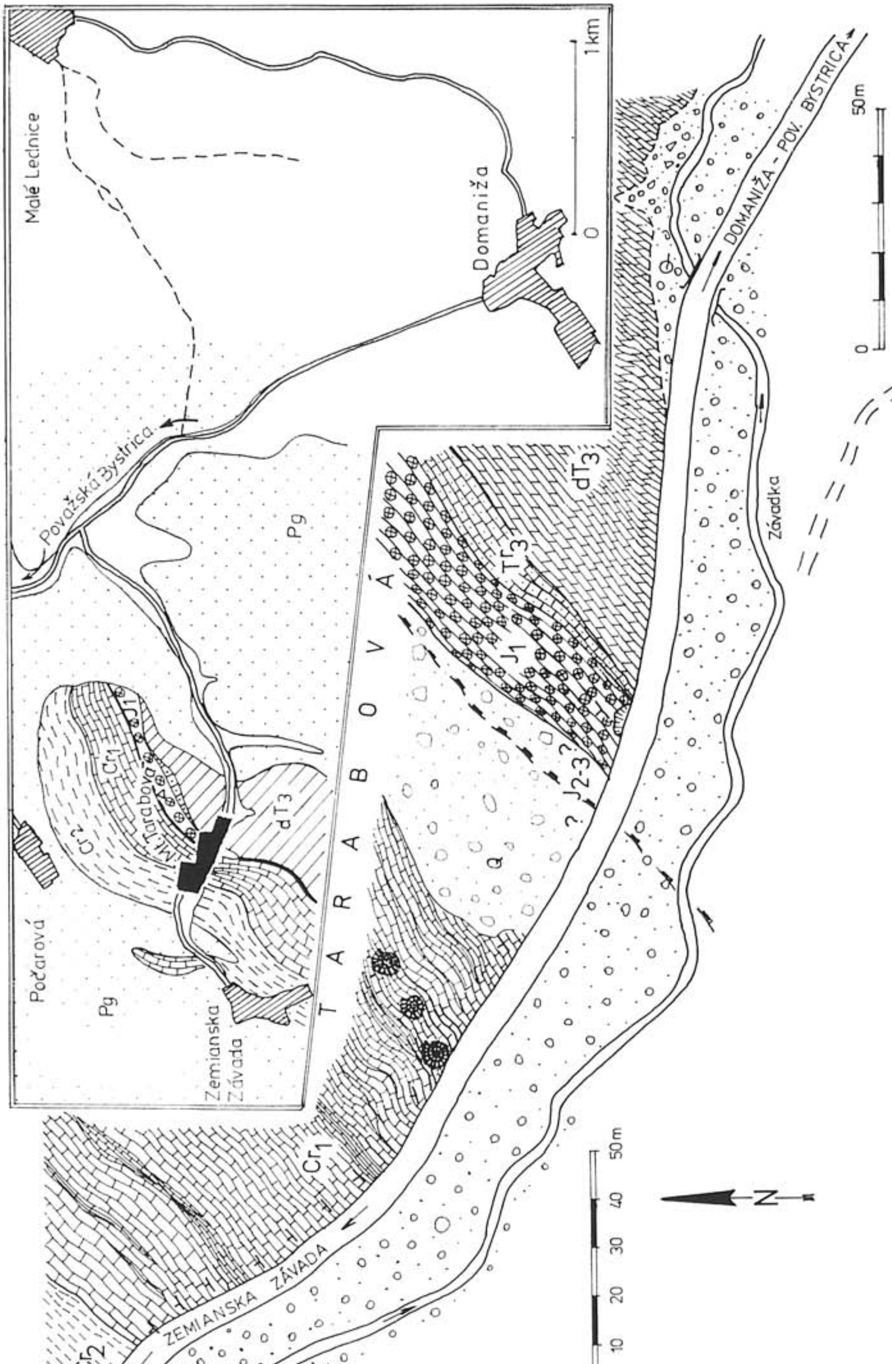
1894—*Crioceras Picteti* "var. *majoricensis*" Nolan; p. 192. Pl. 10, Figs. 1-a,b, 2-d.
—*Crioceras angulicostatus* d'Orbigny; Nolan, p. 195, Pl. 10, Figs. 3-b?,c.
1962—*Crioceratites (Crioc.) majoricensis majoricensis* (Nolan); Wiedmann, p. 118, Pl. 8, Fig. 3.
—*Crioceratites (Crioc.) majoricensis remanei* n. ssp.; Wiedmann, p. 121, Pl. 8, Fig. 4., Pl. 9, Fig. 2.
1977—*Crioceratites (Crioc.) majoricensis* (Nolan); Immel, p. 49, Pl. 7, Fig. b (cum syn.).

Lectotype: Crioceras Picteti "var. *majoricensis*" Nolan, 1894.

Material: eleven, in various degree preserved specimens derived from four localities.

Description: Shells crioceratiform coiled, whorls (especially those ontogenetically younger) of some specimens remain partially in contact. Juvenile sculpture consists of expressive trituberculate main ribs, accompanied by 2—6 additional ones. The external and lateral tubercles gradually disappear in mo-

Fig. 5. A sketch of the geological situation of south-western foot of Tarabová-hill near Zemianska Závada with localisation of the Pseudothurmannia bed outcrops. *Symbols:* Cr_2 - Albian shales of the Krížna-nappe, Cr_1 - Lower Cretaceous limestones with Pseudothurmannia bed, Q - Quaternary cover, J_1 = Liassic crinoidal limestones of the Choč-nappe, Tr_3 - Rhaetian Norovica Limestone Fm. of the Choč-nappe, dT_3 - Upper Triassic dolomites of the Choč-nappe, Pg - Paleogene infilling of the Rajec-basin.


Malé Lednice
Domaniža
0
1km
Považská Bystrica
Pg
Počarová
Zemianska Závada
Mt. Tarabová
Cr1
Cr2
J1
dT3
T A R A B O V Á
J2-3
Q
T3
DOMANIŽA - POV. BYSTRICA
Závadka
50m
ZEMIANSKA ZÁVADA
0
10
20
30
40
50m
N

re mature stages, the difference in expressiveness between the main and additional ribs gradually wipes off during ontogenetical development. Ephebic shell bears only more-or-less expressive umbilical tubercles. Two or three (or two to six) additional ribs disappear in direction to umbilicus. Both the main and additional ribs sometimes bifurcate. A half of juvenile whorl is covered by 7—9 main ribs, whereas equivalent part of ephebic shell bears 8—13 ribs.

Measurement: Specimens of Polomec-Na piate locality yielded the following values (all in the milimeters):

No	D	H	U	U/D	H/D
Pl-III-1/1	43.4	15.7	17.5	0.40	0.36
	38.4	14.1	14.9	0.39	0.39
	29.6	10.6	10.0	0.37	0.39
	23.6	8.6	9.0	0.38	0.36
	18.9	7.6	7.0	0.37	0.40
Pl-III-2/10	29.0	11.6	10.7	0.37	0.40
	23.2	9.0	8.6	0.37	0.39
	20.5	8.5	7.7	0.38	0.41
	16.3	6.3	6.1	0.37	0.39
	12.6	5.0	4.9	0.39	0.40
	10.6	4.3	4.2	0.40	0.41

Geographical distribution: the localities of Polomec-hill (Zabukovinské, Laz, Na piate), Kamenná-hill (Fig. 1).

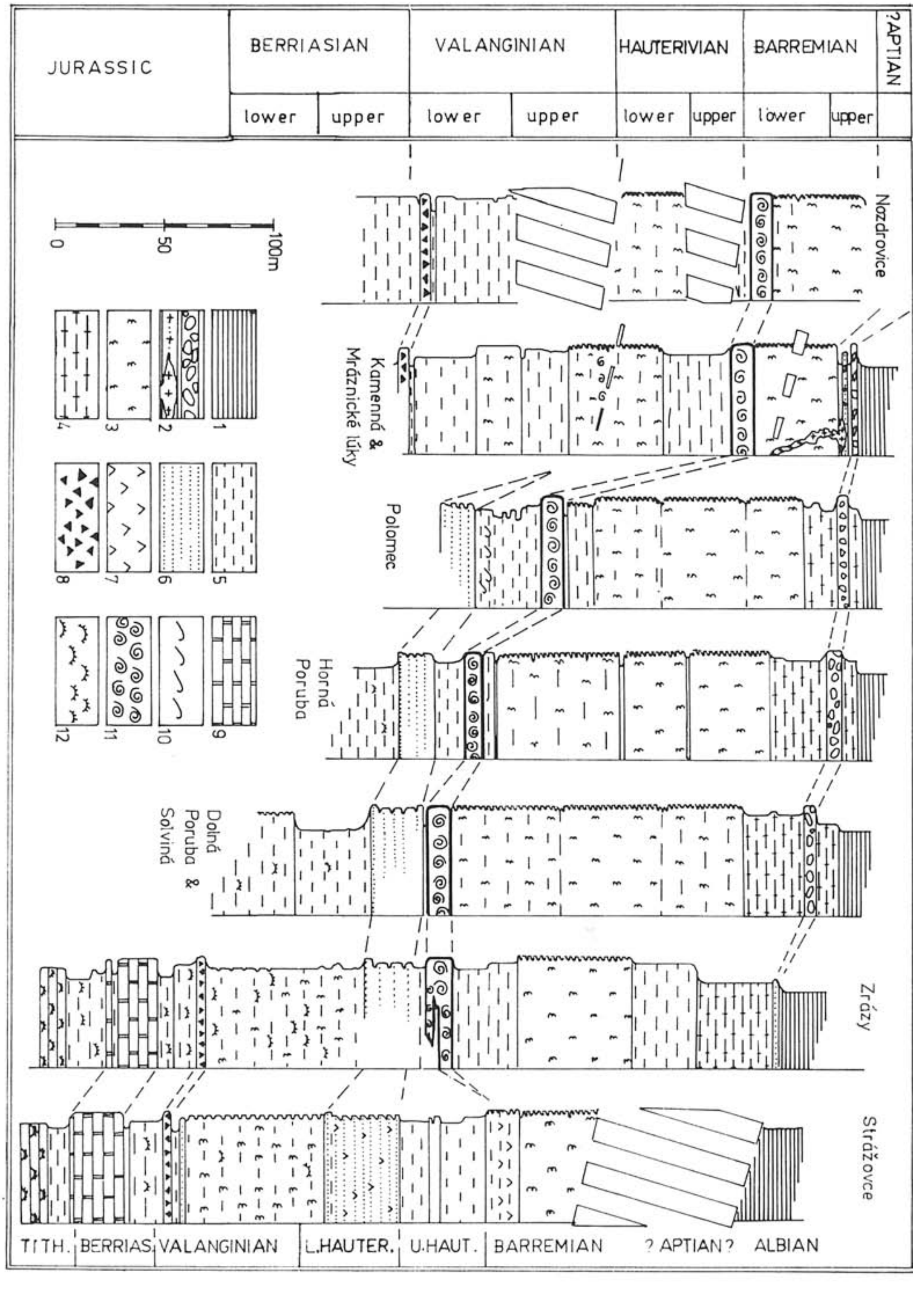
Stratigraphical range: upper Lower Hauterivian to basal Barremian according to Immel, 1978.

Crioceratites (Crioceratites) emerici Léveillé, 1837
Pl. 1., Fig. 3.

1978—*Crioceratites (Crioc.) emerici* Léveillé; Immel, p. 38, Pl. 4, Fig. a (cum syn.).
Holotype: *Crioceratites Emerici* Léveillé, 1837.
Material: 16 variously preserved specimens of 5 localities.

Description: Crioceraticone shells with ribbed ornament. All the ontogenetic shell stages bear differentiated main- and additional ribs. Main ribs of all the stages are expressively trituberculate. They are separated by 4—7 additional ribs in juveniles, but only by 2—4 ribs in ephebic stage. Half-whorl of juveniles is covered by 8—11 main ribs; this number increases to 9—13

Fig. 6. The correlation of seven Lower Cretaceous lithostratigraphical sequences, Krížna-nappe (Zliechov unit) in Strážovské vrchy Mts., with respect to the Pseudothurmannia bed position. *Symbols:* 1 - Albian shales, 2 - limestone breccia, tuffs and basic volcanics of Aptian, 3 - spotted limestones, 4 - marlstones and marls, 5 - marly limestones, 6 - turbiditic complexes, 7 — cherty limestones, 8 - Nozdrovice Breccia Bed, 9 - Biancône limestone, 10 - slumping textures, 11 - Pseudothurmannia bed, 12 - aptychal limestones.


JURASSIC
BERRIASIAN
VALANGINIAN
HAUTERIVIAN
BARREMIAN
?APTIAN
lower
upper
lower
upper
lower
upper
lower
upper
0
50
100m
Nozdrovice
Kamenná & Mráznické lúky
Polomec
Horná Poruba
Dolná Poruba & Solviná
Zrázy
Strážovce
1
2
3
4
5
6
7
8
9
10
11
12
TITH.
BERRIAS.
VALANGINIAN
L.HAUTER.
U.HAUT.
BARREMIAN
? APTIAN ?
ALBIAN

ribs in the maturity. General character of the sculpture does not change during ontogeny, with exception of moderate thickening of the main ribs.

Remarks: Main ribs on the „Pseudothurmannia-bed" specimens are usually less expressive than of specimens derived from overlying beds.

Measurements: Specimens from Polomec-Laz locality offered following data:

No	D	H	U	U/D	H/D
Pl-II-1/8	23.0	9.5	8.6	0.37	0.41
	21.2	8.6	7.8	0.37	0.41
	18.3	7.4	6.6	0.36	0.41
	13.6	5.2	5.4	0.40	0.38
	11.7	4.6	4.8	0.40	0.38
Pl-II-3/18	37.4	10.8	19.2	0.51	0.29
	31.2	9.2	16.0	0.51	0.29
	26.1	8.5	12.9	0.49	0.32
	20.1	7.3	9.3	0.46	0.36
	17.25	6.5	7.8	0.45	0.37
	14.1	4.4	6.6	0.46	0.31

Geographical distribution: Polomec-hill (Lom- and Na piate localites), Tarabová-hill, Kamenná-hill, Solviná-valley.

Stratigraphical range: basal to higher Lower Barremian according to Immel (1978), or Lower Barremian according to Lapeyre (1974).

Crioceratites (Crioceratites) nolani (Kilian, 1910)
Pl. 2, Fig. 1.

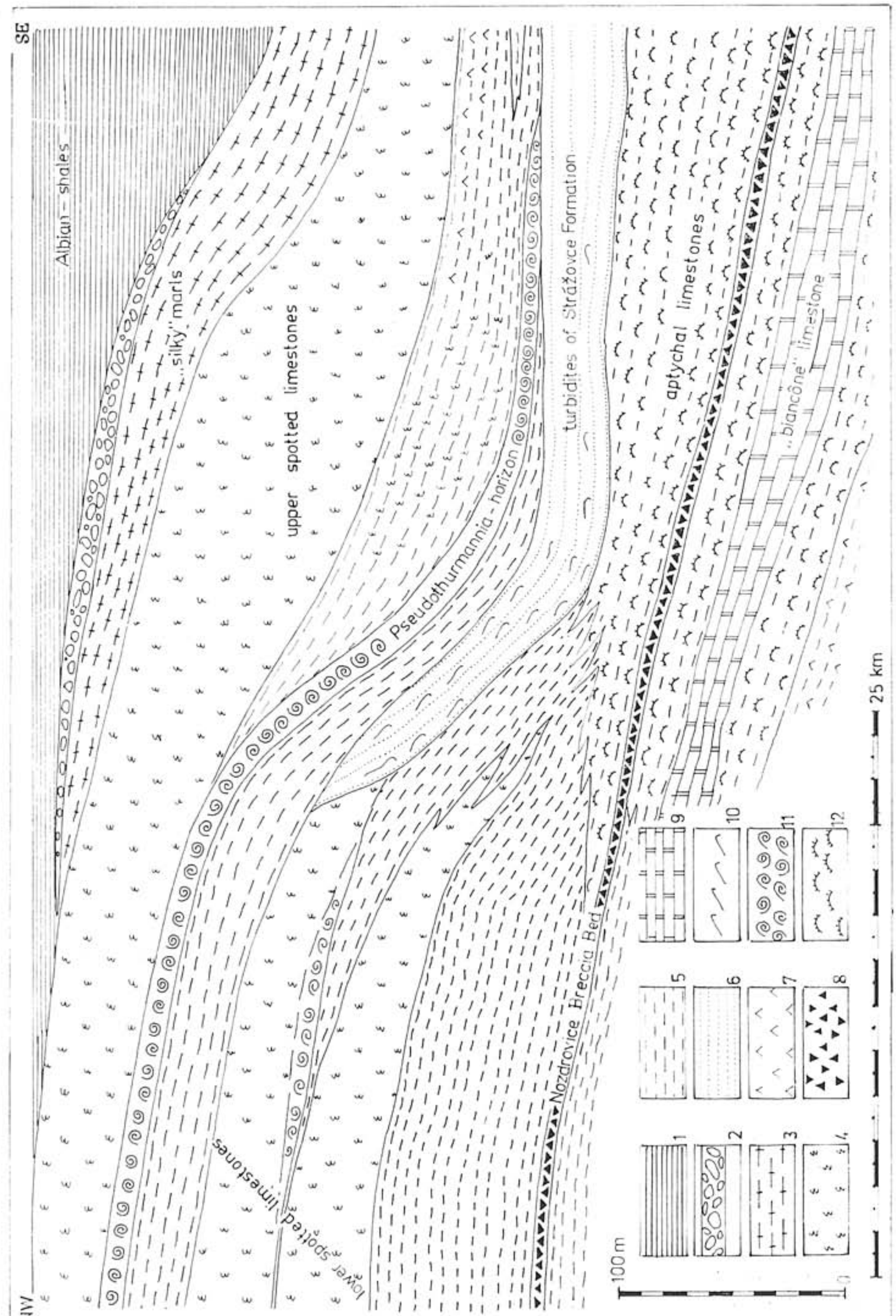
1842—*Crioceras Duvalii* Léveillé in d'Orbigny, p. 459, Pl. 113, Figs. 1—4.
1978—*Crioceratites (Crioc.) nolani* (Kilian); Immel, p. 35., text-f. 3a, Pl. 3, Fig. 3.

Holotype: *Crioceras* Duvalii Léveillé in d'Orbigny, 1842.

Material: Two specimens coming from different localities.

Description: Crioceraticone shells with dense differentiated ribs. Main ribs with umbilical, lateral and external tubercles on all the whorls. Lateral tubercles are sometimes less pronounced than, the others. The interval between two main ribs contains 3—10 additional ribs, 2—5 of them being inserted. Half-whorl bears 9 main ribs.

Fig. 7. A scheme of lithostratigraphical and (partially) bathymetrical relations between sedimentary formations studied. *Symbols:* 1 - shales, 2 - paraconglomerates, 3 - „silky" marls, 4 - spotted limestones, 5 - marlstones, 6 - allodapic limestones, 7 - cherty limestones, 8 - breccias, 9 - micrital limestones of „Biancône" — type, 10 - slumping textures, 11 - Pseudothurmannia bed, and similar concentrations of ammonoid shells, 12 - aptychal limestones.


NW
SE
Albian - shales
„silky" marls
upper spotted limestones
Pseudothurmannia - horizon
turbidites of Strážovce Formation
aptychal limestones
„biancône" limestone
lower spotted limestones
Nozdrovice Breccia Bed
100 m
0
25 km
1
2
3
4
5
6
7
8
9
10
11
12

Measurements: The specimen from Na piate (Polomec) locality yielded this data:

No	D	H	U	U/D	H/D
Pl-III-3/45	86.1	33.0	34.0	0.39	0.38
	63.5	24.8	23.8	0.37	0.39
	37.5	15.6	13.3	0.35	0.41

Remarks: Beside of the less pronounced trituberculation of main ribs, this species differs from *(C. (C.) emerici* predominantly by smaller number of main ribs on the half of the last whorl (9 ribs when compared with 13 ribs of ephebic half-whorl of *C. (C.) emerici* cf- Immel, 1978).

Geographical distribution: Polomec-Na piate locality; Kamenná-hill.

Stratigraphical range: very wide, when compared with other species of this genus: lower Lower Hauterivian to basal Barremian according to Immel, 1978.

Crioceratites (Crioceratites) quenstedti (Ooster, 1860)
Pl. 1., Fig. 2.

1849—*Crioceras Duvalii* d'Orbigny; Quenstedt, Pl. 20, Fig. 13.
1978—*Crioceratites (Crioc.) quenstedti* (Ooster); Immel, p. 44, Pl. 1, Fig. 3, Pl. 3 ,Figs. 1—2 (cum syn.)

Holotype: *Crioceras Duvalii* d'Orbigny in Quenstedt, 1849.

Material: one damaged shell.

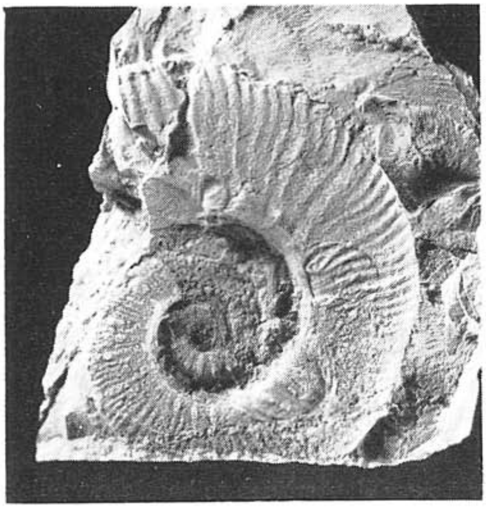
Description: Little coiled shell, inner whorls covered by fine, dense, equally thick ribs. Some ribs converge to umbilicus, forming bands. Differentiation of ribs, which arose from small elongated tubercles on umbilical side of whorls begins in shell diameter 25 mm; duplication of main ribs (two parallel ribs being separated by inexpressive groove) appears in shell diameter greater than 30 mm. The external tubercles are developed blankly. The interval between two main ribs contains 4—6 additional ribs, 1—2 of them being inserted. The surface of the last half-whorl of mature shell has 8 main ribs.

Measurement: Specimen from Polomec-Na piate locality yielded the following data (in mm):

No	D	H	U	U/D	H/D
Pl-III-38	43.6	16.6	16.8	0.39	0.38
	27.1	10.0	10.2	0.37	0.38
	19.0	7.1	7.2	0.37	0.38

Geographical distribution: Polomec-hill (Na piate-loc.).

Stratigraphical range: higher Lower Hauterivian-basal Barremian (cf. Immel, 1978).



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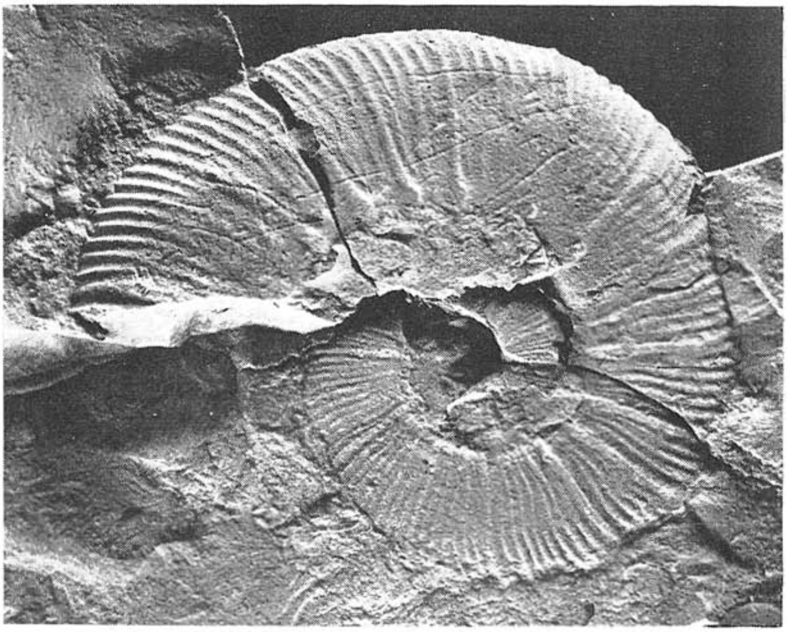

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Plate 1

Fig. 1. *Crioceratites (Crioceratites) majoricensis* (Nolan). Kamenná-hill, Kms 530 54.

Fig. 2. *Crioceratites (C.) quenstedti* (Ooster). Polomec quarry, Na piate locality, Pl—3—3/8.

Fig. 3. *Crioceratites (C.) nolani* (Kilian). Polomec quarry, Na piate locality, Pl—3—2 45. All specimens shown in their natural size.

Crioceratites (Crioceratites) matsumotoi (Sarkar, 1955)
Pl. 2., Fig. 1.

1849—*Crioceras Villiersianus* d'Orbigny; Quenstedt, Pl. 20, Fig. 12
1955—*Crioceras matsumotoi* Sarkar, p. 74., Pl. 3, Fig. 2.
1978—*Crioceratites (Crioc.) matsumotoi* (Sarkar); Immel, p. 37, text-fig. 3-c, Pl. 2., Figs. 5—6 (cum syn.)

Holotype: *Crioceras matsumotoi* Sarkar, 1955.

Material: A sole specimen with uncertainly preserved inner whorls.

Description: Juvenile whorls of tightly crioceraticone shell have dense, undifferentiated ribs. The first main ribs with umbilical tubercles appear by whorl diameter greater than 40 mm. Main ribs of ephebic shell have pronounced umbilical tubercles but the external ones are less expressive. The space between two main ribs contains 3—4 additional ribs, 2—4 of them being inserted.

Remarks: When compared with the type material, the umbilical tubercles of our specimen are much better developed.

Geographical distribution: Polomec-Na piate locality.

Stratigraphical range: upper Lower Hauterivian to basal Barremian according to Immel (1978).

Subgenus *Pseudothurmannia* Spath, 1923

Type-species: *Ammonites angulicostatus* d'Orbigny, 1841. Lower Barremian of southeast France.

Crioceratites (Pseudothurmannia) mortilleti (Pictet et Loriol, 1858)
Pl. 2., Fig. 3.

1962—*Crioceratites (Pseudoth.) mortilleti mortilleti* (Pict. et Lor.); Wiedmann, p. 132, Pl. 7., Fig. 5.
1978—*Crioceratites (Pseudoth.) mortilleti* (Pict. et Lor.), Immel, p. 67, text-fig. 13-a, Pl. 1, Fig. 2 (cum syn.)

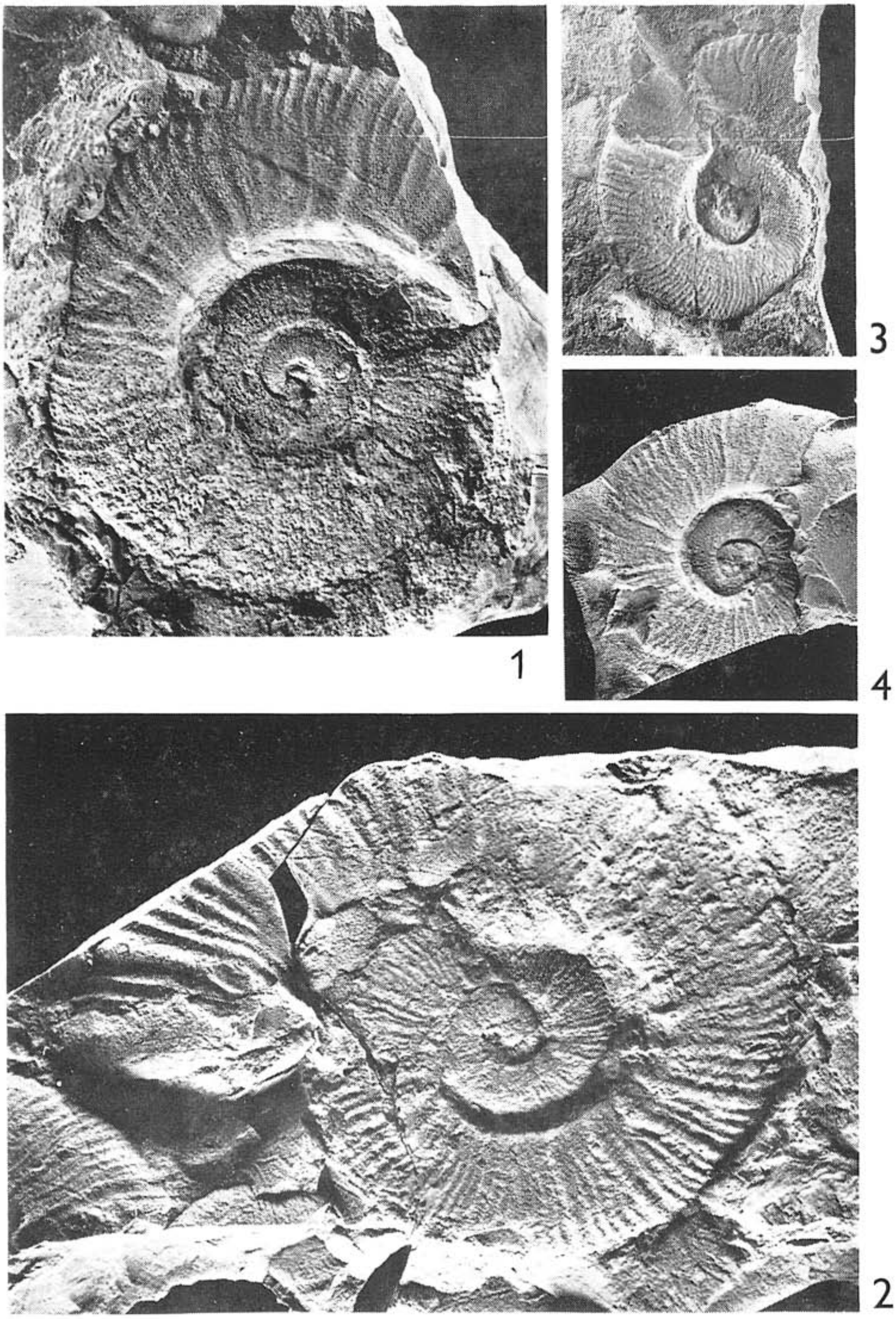
Lectotype: *Hoplites Mortilleti* Pictet et Loriol in Sarasin et Schoendelmayer, 1901.

Material: Twelve specimens derived from four localities.

Description: Juvenile whorls of evolute shells have undifferentiated dense ribs. Main ribs with tiny umbilical tubercles differentiate in more mature stage. However, the difference in expressiveness between the main and additional ribs is not significant even on the last whorl. Two main ribs are separated by 2—4 additional ribs, 1—2 of them being inserted or bifurcated.

Plate 2

Fig. 2. *Crioceratites (C.) emerici* (Léveillé). Polomec quarry, Na piate locality, Pl.—3—2/27.
Pl.—3—2/51. Specimen with thin primary ribs and weak lateral tubercles.
Fig. 3. *Crioceratites (Pseudothurmania) mortilleti* (Pict. et Loriol). Polomec quarry, Zabukovinské locality, Pl.—1—5/3.
Fig. 4. *Crioceratites (Pseudoth.) belimelensis* Dimitrova. Polomec quarry, Laz locality, Pl—2—1/10.
All specimens are shown in their natural size. Photographs by M. Grmelová, Ostrava. Prior to photographing the specimens were whitened with ammonium chloride. All the specimens are housed in collections of the Slovak National Museum, Bratislava.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Measurements: The following data have been obtained on specimens from Polomec-hill (Zabukovinské, Laz and Na piate localities):

No	D	H	U	U/D	H/D
Pl-II-1/10	38.6	15.0	14.2	0.37	0.39
	35.6	14.3	12.9	0.36	0.40
	31.4	12.45	11.8	0.38	0.40
Pl-III-1/2	27.4	11.4	8.8	0.32	0.42
	23.3	10.4	7.7	0.33	0.45
	20.25	8.7	6.6	0.33	0.43
Pl-I-5/3	38.3	14.95	12.8	0.33	0.39
	33.2	13.9	10.35	0.31	0.42
	28.2	12.7	8.35	0.29	0.45

Remarks: The sculpture is rather variable: whereas the ribs of some 40 mm diameter specimens are undifferentiated, the others, of comparable size, have each two mature ribs accompanied by 6—8 additional ribs.

Geographical distribution: Polomec-hill (the Zabukovinské, Laz and Na piate-localities), Kamenná-hill.

Stratigraphical range: basal Barremian (Immel, 1978).

Crioceratites (Pseudothurmannia) belimelensis (Dimitrova, 1967)
Pl. 2., Fig. 4.

1967—*Pseudothurmannia belimelensis* sp. n.; Dimitrova, p. 75., Pl. 31, Fig. 2.
1976—*Pseudoth. belimelensis* Dimitrova; Mandov, p. 66., Pl. 9., Fig. 1.

Holotype: *Pseudothurmannia belimelensis* Dimitrova, 1967.

Material: seven variously preserved specimens of three localities.

Description: Evolute coiled shells covered with fine dense ribs. The differentiation of main ribs, distinguishable already on juveniles, becomes expressive during ontogeny. Umbilical tubercles on main ribs are variously pronounced. Interval between two main ribs is filled by 2—4 additional ribs, 1—2 of them being inserted. In some sections of certain shells, main ribs are separated by sole additional rib. A half-whorl bears 9—12 main ribs.

Measurement: (the Polomec-Laz locality):

No	D	H	U	U/D	H/D
Pl-II-1/28	27.8	10.6	9.9	0.36	0.38
	21.2	8.4	7.3	0.34	0.40
Pl-II-1/13	38.6	14.7	13.5	0.35	0.38
	34.5	12.5	12.3	0.36	0.37
	32.2	12.0	11.95	0.37	0.37
Pl-II-1/10	41.2	14.6	15.3	0.37	0.35
	39.2	13.0	15.0	0.38	0.33
	31.9	11.3	12.4	0.39	0.35

Table 1
Principal morphological features of the species described, and theirs mutual correlation

Tubercle type	EXTERNAL	+	+	(+)	+	+	—	(+)
	LATERAL	+	+	—	+	—	—	—
	UMBILICAL	+	+	+	+	+	+	+
Number of additional ribs		2—6	2—7	3—8	3—10	4—6	2—4	2—4
Number of main ribs on a half-whorl	EPHEBIC WHORL	8—13	9—12	7	9	8	—	9—12
	JUVENILE WHORL	7—9	8—10	—	—	—	—	—
Differentiation of ribs	EPHEBIC WHORL	+	+	+	+	+	+	+
	MIDDLE WHORLS	+	+	(+)	+	—	—	+
	JUVENILE WHORLS	+	+	—	—	—	—	(+)
Maximum diameter (D) in mm		50	100	75	90	50	45	42
Species described		*C.(C.) majoricensis*	*C.(C.) emerici*	*C.(C.) matsumotoi*	*C.(C.) nolani*	*C.(C.) quenstedti*	*C.(P.) mortilleti*	*C.(P.) belimelensis*

Table 2
Composition of cephalopod fauna of individual localities

Cephalopod species represented \ Localities evaluated	Polomec III (Na piate)	Polomec II (Laz)	Kamenná near Košeca	Tarabová near Z. Závada	Solviná near D. Poruba	Zrázy near Dolná Poruba
Crioceratites (C.) emerici Léveillé	+	+	+	+	+	+
C. (C.) majoricensis (Nolan)	+	+	+	–	–	+
C. (C.) matsumotoi (Sarkar)	?	–	–	–	–	–
C. (C.) nolani (Kilian)	+	–	+	–	–	–
C. (C.) quenstedti (Ooster)	+	–	–	–	–	–
C. (Pseudothurmannia) sp.	+	+	+	+	+	+
C. (P.) mortilleti (Pictet et Loriol)	+	+	+	–	–	+
C. (P.) belimelensis (Dimitrova)	+	+	+	–	–	–
Phylloceras (Hypophylloceras) sp.	+	–	+	+	+	+
Barremites (Barremites) sp.	+	+	+	+	+	–
Partschiceras infundibulum (d'Orbigny)	–	–	+	–	–	–
Anahamulina sp.	?	–	+	–	–	+
Acrioceras sp.	+	+	?	–	+	–
Lytoceras sp.	–	?	–	–	–	–
Eulytoceras sp.	?	–	–	–	–	–
Lamellaptychus sp.	+	+	+	+	+	–
L. ex gr. *angulicostatus* (Pictet et Lor.)	+	+	–	–	–	–
Hibolites sp.	+	–	+	+	–	–
H. ex gr. *jaculoides* Swinnerton	+	–	–	–	–	–
Duvalia sp.	–	+	–	+	–	–

Geographical distribution: Polomec-hill (the Laz- and Na piate localities) and Kamenná-hill.

Stratigraphical range: limited on Upper Hauterivian according to Dimitrova (1967) and Mandov (1976). However, Lapeyre (1974) and Lapeyre-Thomel (1974) suppose that this species has similar distribution like *C. (P.) angulicostata* (=Lower Barremian).

Principal morphological features and differences between the species described are summarized in the following table (Tab. 1.).

Stratigraphy

Exact stratigraphical position of the Angulicostata Zone, the key-horizon for understanding of Hauterivian-Barremian boundary, has been controversial for a long time. Immel (1978) introduced a survey of complicated development of view on this problem.

The contradictions were caused also by the fact that the *Crioceratites (Pseudoth.) angulicostata* type-specimen has been lost and the original d'Orbigny's

Table 3a
Comparisons of dominance according Simpson's index of dominance

Taxon	Polomec Laz	Polomec Na Piate	Kamenná	Tarabová	Solviná
crioceratids	27	75	81	41	32
Crioceratites	22	66	72	39	31
Pseudothurmannia	5	9	9	2	1
Barremites (B.)	2	17	10	6	3
Phylloceras (Hypophylloceras)	—	3	1	1	1
Acrioceras	1	1	1	—	1
Anahamulina	—	2	3	—	—
Partschiceras	—	—	3	—	—
Lytoceras	1	—	—	—	—
Eulytoceras	—	1	—	—	—
Hibolites	—	1	1	1	—
Lamellaptychus	1	10	2	1	3
Duvalia	2	—	—	1	—
Total number (N)	34	110	102	51	40
Simpson's index	0,64	0,50	0,64	0,66	0.65

Table 3b
Percentual share of cephalopod remains in individual localities

Taxon	Laz	Na piate	Kamenná	Tarabová	Solviná	Zrázy
Total crioceratids	79	68	79	80	80	89
Crioceratites (Crioceratites)	65	60	70	76	77	85
Crioceratites (Pseudothurmannia)	14	8	9	4	3	4
other ammonoids	12	22	18	13	13	11
aptychi	3	9	2	3	7	—
belemnites	6	1	1	4	—	—

picture (1840) was a pure imprecise reconstruction only (cf. Lapeyre, 1974). The latter author has been successful in erecting of the neotype: he, together with Thomel brought also new data on accompanying species. With regard to co-occurrence of described species containing indisputable Lower Barremian *Crioceratites (C.) emerici* Léveillé and *Psilotissotia favrei* (Ooster), *C. (C.) thiollierei* (Astier) and *Paraspiticeras ex gr. percevali* (Uhlig), there is necessary to consider the age of Pseudothurmannia bed not to be Late Hauterivian (like many previous authors), but, in agreement with Immel, 1979 as Early Barremian.

Individual localities, we investigated, yielded associations of cephalopod faunal remnants, summarized in the Tab. 2.

Quantitative evalution of faunal diversity and, partially, also the quantitative analysis is influenced by inconsistent preservation of ammonite shells (particulary on the last three localities): they are preserved in form of sculptural moulds, often affected by diagenetic deformations, by hematitization of pyrite infillings in juvenile whorls, and by post-diagenetic dissolution. Dominating cephalopod remains are accompanied by sole brachiopod and gastropod shells. Percentual share of cephalopod taxa found in individual localities is surveyed in the Table 3. Fossil associations, of individual localities usually contain only a small percentage of high abundant genera; specimens of the remaining genera occur more rarely.

Table 4
Comparison of diversity of individual localities with application of Kimoto's similarity index

Locality					
Polomec-hill, Laz-quarry	0				
Polomec-hill, Na piate-quarry	0.97	0			
Kamenná – hill	0.99	0.99	0		
Tarabová – hill	0.99	0.98	0.99	0	
Solviná – valley	0.99	0.98	0.99	0.99	0

The calculation of Simpson's dominance index is one of the best methods expressing of dominance in faunal association of one locality (cf. Tanabe, 1979). It is expressed by the relation (Odum, 1977):

$$C = \sum \frac{n_i^2}{N}$$

where n_i is the number of individuals belonging to one genus, and N is the total number of individuals of given locality. Simpson's index C obtains value between 1/N and 1 (the latter case means the monotypical association (Simpson, 1949)).

In the study of faunistic associations we applied the Kimoto's similarity index, originally developed for comparison of several Upper Cretaceous ammonite associations (Tanabe, 1979). This index, comparing the pairs of localities, is expressed by the formula:

$$C\pi = \frac{2 \sum_{i_1}^{s} n_{1_i} \cdot n_{2_i}}{(\sum_{i=1}^{s} n_{1_i}^2 / N_1^2 - \sum_{i=1}^{s} n_{2_i}^2 / N_2^2)\, N_1 \cdot N_2}$$

where N_1 and N_2 are the total numbers of specimens of two localities, n_{1_i} and n_{2_i} are numbers of specimens of i-th genus in these localities, s means the total number of genera, forming both the associations. Kimoto's index $C\pi$ obtains the values between 0 and 1 (the latter case means the identical faunistical associations). Both the indexes are fully applicable only in associations, consisting of 30 specimens at least. Therefore, we focused our attention on five localities with total number 337 specimens, belonging to eleven genera (8 ammonite-, 2 belemnite-, 1 aptychal genus). The results of both the correlations are surveyed in the tables.

Ecological remarks

As all the dominant groups of assemblage of the preserved organic remnants belong to a single trophic category (nektobenthic to nektonic macro- and microcarnivores), whereas the remnants of their potential prey are preserved scarcely, the composition of the original assemblage must have been substantialy different.

Infrequent hard-shelled benthic organisms (brachiopods or even more rare gastropods) evidently could not fill the missing lower stage of ecological trophic pyramide. Low intensity of bioturbation indicate that neither soft-bodied infaunal organisms could played this rôle. The benthos has been rather low differentiated and infrequent, owing to too soft substrate. Brachiopods and cemented bivalves *(Plicatula)* were attached to hard objects (ammonite shells or their fragments). Planktic organism, soft-bodied nekton and microbenthos have been probably the main food producers for carnivorous cephalopods. Thus, the "Pseudothurmannia-association" represents a typical thanatocoenosis, consisting of organism remains, living above bottom in different layers of water environment. Despite of it, fragile shells were transported probably on a rather short distance and the areal of their occurrence approximatively overlapped with their life area.

The representatives of the genus *Crioceratites* have had an expressively dominant position in faunal association of all the localities correlated (Simpson's index obtain values between 0.5—0.66). This phenomenon deserves a special attention, being observed in a single horizon in all the compared, relatively distant localities. Moreover, the Kimoto's index values are extremely similar (if not identical) in all the localities compared. The results of both the methods proves that all the localities followed formed a part of a single, stratigraphically (=basal Barremian) and geographically homogeneous horizon. Its faunistical association show a remarkably stable composition in the area investigated (having several hundreds km^2 in extension during Early Cretaceous time).

After sinking onto bottom surface, the shells were not long exposed to destructional agents, as the sedimentation rate (although much slower than in the lower- and highermore horizons) was sufficiently high. Internal cavity of juvenile whorls was filled with pyrite shortly after burial, being limonitized at present. The shell aragonite dissolved in early diagenetic stage, ammonite remnants are preserved as sculptural moulds. These moulds were mostly deformed by vertical pressure. All these facts indicate relatively well aerated sedimentary environment close below the ACD-level. The oxygen deficit level ran shallow under surface of the soft, weakly consolidated sediment, accompanied by sulphide production from decaying organic matter, locally accumulating in closed hollows.

Conclusions

1. The paper gives a survey of occurrence, taxonomy, stratigraphical distribution and ecology of Lower Barremian crioceratids in Krížna-nappe of Strážovské vrchy Mts.

2. Both the horizontal and vertical distribution of described forms in the sections examinated indicate presence of an extensive (the distant pair of localities is about 50 km apart, measured after the Alpine space-deformation!) and stratigraphically homogeneous Pseudothurmannia-bed. This bed can serve as a "marker-horizon" denoting the base of Barremian deposits in the extensive Krížna-nappe bodies.

3. The Pseudothurmannia-bed is characteristic member of Krížna-nappe sequence. Statistical analysis and faunal similarity tests indicate a possible paleogeographical identity of localities compared, ranged recently to different tectonic units.

4. The analysis of sedimentological features in investigated horizon and the ecological pecularities of faunal associations allow us to recognize the principal attributes of the ancient sedimentary- and life environment: moderate slackening of sedimentation rate, decrease in bioturbation activity of infaunal organisms, fairly soft bottom (with only scarce benthic fauna) below the ACD level, local anoxic conditions below the surface of the sediment, shell accumulation of nektobenthic and nektic cephalopods, living in several water levels of sea environment, limited transport by currents. The origin of faunal concentrations and those of Pseudothurmannia bed distribution in the West Carpathian- and, especially, in the Fatric sedimentary area, are not satisfactorily explained till now.

Translated by J. Vitko

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Review by M. RAKÚS Manuscript received June 9, 1982