Mitt. Geol.-Paläont. Inst. Univ. Hamburg	Heft 77	Seite 221-241	Hamburg, Mai 1996

Aptychi and stratigraphy of the Lower Cretaceous in the Western Carpathians

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Abstract

Rich occurrences of aptychi in Lower Cretaceous pelagic deposits in the inner part of the Outer and in the Central Carpathians of the Czech and Slovak territories allow their use as biostratigraphic markers where ammonites or other fauna are imperfectly preserved or absent. This contribution presents the stratigraphic significance of aptychi based on the morphological development and a conspicuous species diversification of *Punctaptychus* during Berriasian. A great diversity of forms is also observed in Berriasian *Lamellaptychus*. The latter genus reached its maximal diversification in the Lower Valanginian but shows reduced variability in the Upper Valanginian. In the Lower Hauterivian there are only two important species of *Lamellaptychus*, which predominate, the last occurrences correspond to the Lower and Upper Hauterivian boundary. The Upper Hauterivian is characterised by the last lamellaptychi (with angular bounded ribs) which do not survive the Hauterivian-Barremian boundary.

Zusammenfassung

Aptychen-Stratigraphie der Unterkreide in den tschechischen und slowakischen Westkarpaten.

Das reiche Vorkommen von Aptychen in den unterkretazischen pelagischen Sedimenten von Tiefwassercharakter in den inneren Teilen der Außen- und in den Zentralen Karpaten auf tschechischem und slowakischem Gebiet erlaubt eine biostratigraphische Nutzung der Aptychen überall dort, wo Ammoniten oder andere Makrofaunen fehlen oder nur ungenügend erhalten sind. Der vorliegende Beitrag zeigt die stratigraphische Bedeutung der Aptychen auf, die auf der morphologischen Entwicklung und einer beträchtlichen Artdiversifikation von *Punctaptychus* im Berrias beruht. Eine beträchtliche Vielfältigkeit erreichen auch die Vertreter der Gattung *Lamellaptychus* im Berrias. Diese Gattung, die ihre maximale Diversifikation im unteren Valangin erreicht, verliert ab dem oberen Valangin an Variabilität. Im unteren Hauterive dominieren nur zwei wichtige *Lamellaptychus*-Arten, deren letztes Vorkommen der Grenze zwischen dem unteren und oberen Hauterive entsprechen. Das obere Hauterive ist durch die letzten Lamellaptychen (mit abgewinkelten Rippen) charakterisiert, die die Hauterive-Barreme-Grenze nicht überleben.

Introduction

The Czech and Slovak territories consist of two basic units from the geological point of view: the Bohemian Massif, consolidated by the Variscan orogeny (in the Czech Republic), and the Carpathian System, consolidated by the Alpine orogeny. As follows from the geological map of the Czech and Slovak Republics, marine Lower Cretaceous sediments occupy a relatively large region in the east part of former Czechoslovakia. They are united to the Western Carpathian mountain range and belong to the European Alpine orogen belt with a compli-

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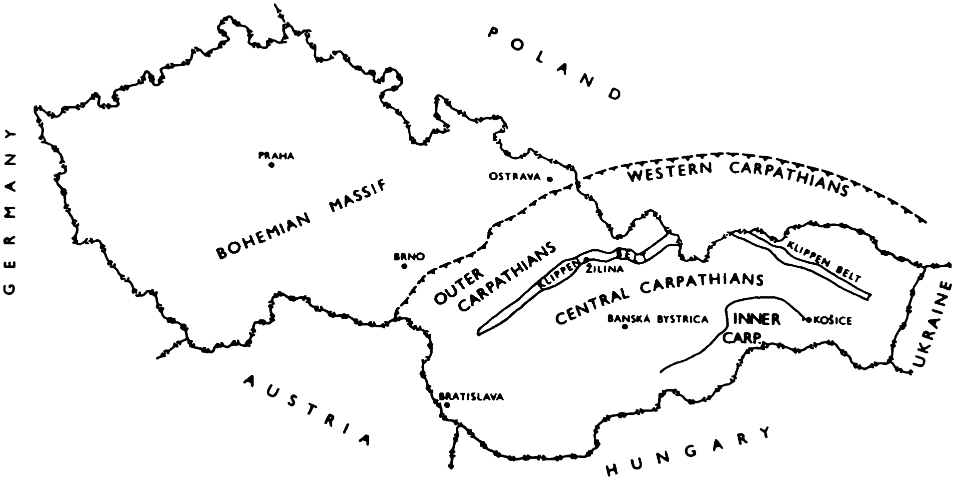

Fig. 1: Overview of studied area.

cated nappe structure. Based on the palinspastic situation, development and the resulting structure of the Western Carpathian system, there are the Outer or Flysch Carpathians, Central Carpathians and Inner Carpathians (Fig. 1). The

Explanations to Fig. 2

1 – *Punctaptychus punctatus punctatus* (VOLTZ)
2 – *Punctaptychus punctatus rectecostatus* CUZZI
3 – *Punctaptychus punctatus fractocostatus* TRAUTH
4 – *Punctaptychus cinctus* TRAUTH
5 – *Lamellaptychus beyrichi* (OPPEL)
6 – *Lamellaptychus rectecostatus* (PETERS)
7 – *Lamellaptychus submortilleti* TRAUTH
8 – *Lamellaptychus cinctus* TURCULET
9 – *Lamellaptychus studeri* (OOSTER)
10 – *Lamellaptychus* sp. 1
11 – *Lamellaptychus herthae* (WINKLER)
12 – *Lamellaptychus mortilleti mortilleti* (PICTET & LORIOL)
13 – *Lamellaptychus mortilleti radiatus* STEFANOV
14 – *Lamellaptychus lorioli* RENZ
15 – *Lamellaptychus mendrisiensis* RENZ & HABICHT
16 – *Lamellaptychus mortilleti noricus* TRAUTH
17 – *Lamellaptychus helveticus* RENZ & HABICHT
18 – *Lamellaptychus stellariformis* RENZ
19 – *Lamellaptychus bicurvatus* RENZ & HABICHT
20 - *Lamellaptychus beyrichodidayi* TRAUTH
21 - *Lamellaptychus didayi* (COQUAND)
22 – *Lamellaptychus seranonis seranonis* (COQUAND)
23 – *Lamellaptychus atlanticus* (HENNIG)
24 – *Lamellaptychus cristobalensis* (O'CONELL)
25 – *Lamellaptychus seranonis* ssp. 1
26 – *Lamellaptychus angulocostatus angulocostatus* (PETERS)
27 - *Lamellaptychus angulocostatus radiatus* TRAUTH
28 – *Lamellaptychus angulocostatus angulicostatus* (PICTET & LORIOL)
29 – *Lamellaptychus filicostatus* STEFANOV
30 – *Lamellaptychus aplanatus aplanatus* (PETERS)
31 – *Lamellaptychus aplanatus latus* TRAUTH
32 – *Lamellaptychus excavatus* TRAUTH
33 – *Lamellaptychus bermudensis* RENZ
34 – *Lamellaptychus trauthi* RENZ & HABICHT
35 – *Lamellaptychus symphysocostatus* TRAUTH
36 – *Lamellaptychus retroflexus* TRAUTH
37 – *Lamellaptychus noricus* (WINKLER)

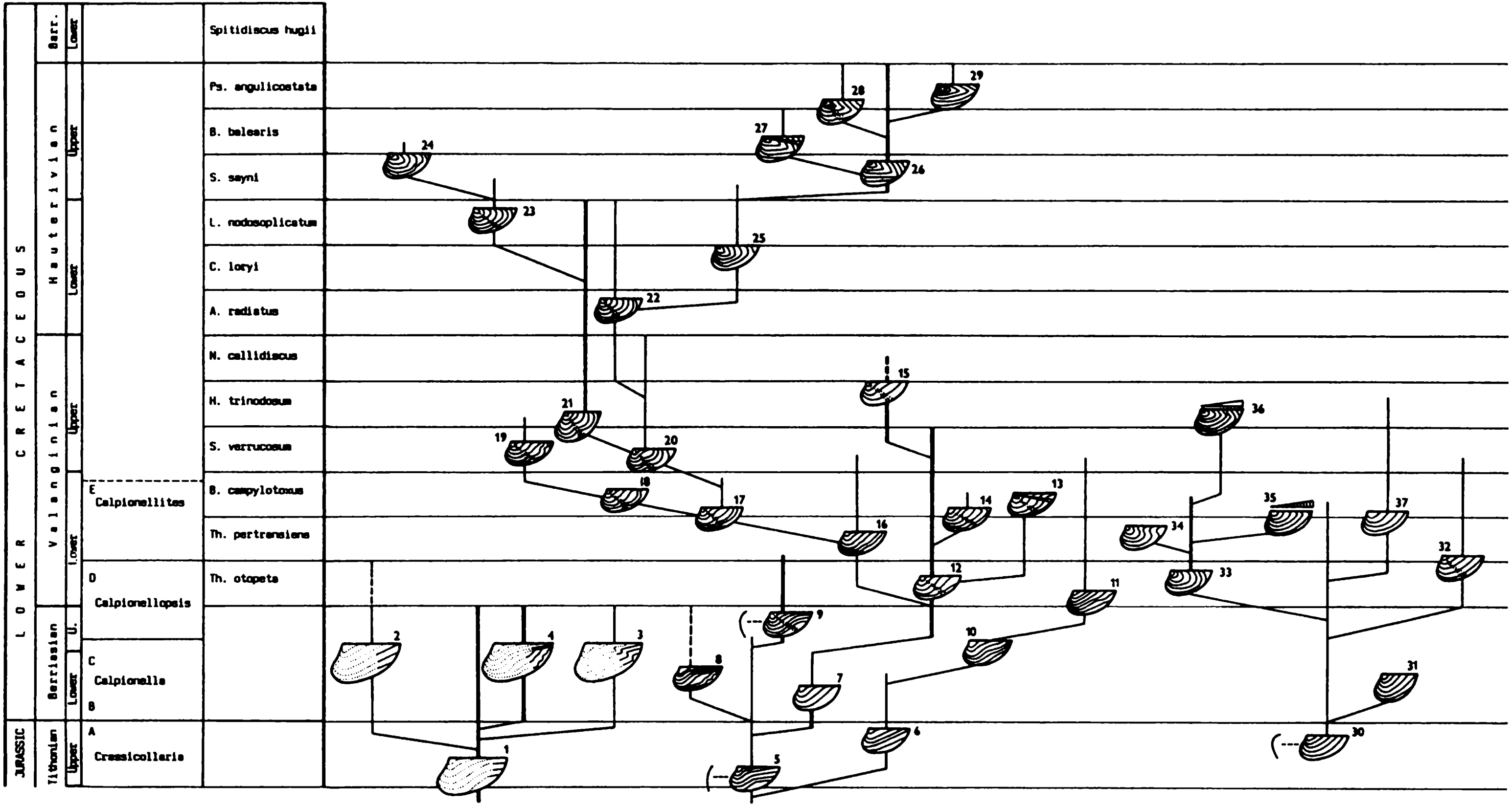

Fig. 2: Scheme of development and distribution of the Lower Cretaceous aptychi in the Western Carpathians.

tectonofacies units of higher order, such as the Beskidic, Oravic, Vahic, Tatric, Fatric and others are distinguished, further divided into sedimentary basins separated by partial ridges as seen in palaeotectonic schemes (f. e. MICHALÍK & SOTAK, 1990, VAŠÍČEK et al., 1994).

A significant proportion of the known Lower Cretaceous sediments in the Outer and Central Carpathians is represented by pelagic deep-water sediments consisting largely of light-green marly limestones. In many cases cherts are present in these limestones. Because of the nappe structure the sediments are often tectonically stressed and the sequences of strata are usually complicated by dislocations.

From the macrofaunal point of view, these pelagic sediments are rather poorly fossiliferous. They usually contain only cephalopods, i. e. moulds of ammonites and calcite aptychi, sometimes, however, only aptychi.

Carpathian aptychi assemblages

Calcite aptychi occur in the Lower Cretaceous sediments of the Western Carpathians either dispersed or in specific aptychi lumachelles or in conglomerates of turbidite origin.

The outer morphology of aptychi, which were originally considered to be ammonite opercula, later their lower jaws, and finally both (LEHMANN & KULICKI, 1990), is relatively simple. Apart from the shape and convexity of valves, the course and configuration of lamellar ribs in the terminal area are important distinguishing characters. The artificial classification of aptychi operates with taxons on the level of genera, species and subspecies.

Hundreds of aptychi from many Carpathian localities under study were collected during the last two decades and analysed systematically TRAUTH (1935, 1938), GASIOROWSKI (1962 a, b, etc.), RENZ (1978, 1983), RENZ & HABICHT (1985) and others, resulting in the development of a Lower Cretaceous parabiostratigraphic scale based on aptychi. The stratigraphic position and the extent of the determined aptychi (Fig. 2) follow the Mediterranean Lower Cretaceous ammonite zonation defined in Digne (HOEDEMAEKER & BULOT, 1990), and for the Berriasian and the Lower Valanginian it accords with the calpionellid zone and also some of our results published earlier (VAŠÍČEK & al., 1983; MICHALÍK & al., 1990 a, b, 1993; VAŠÍČEK, 1992, VAŠÍČEK & al. 1992, 1994, and others).

The main results as to the occurrence, development and distribution of the aptychi in the Lower Cretaceous of the Czech and Slovak Carpathians are as follows:

The sediments of the uppermost Jurassic and lowermost Cretaceous are usually characteristed by the simultaneous occurrence of *Punctaptychus punctatus* and *Lamellaptychus beyrichi* (Figs. I/1-3, II/3). Their morphological development is formed as costation on the valve surface exactly parallel, as there occur equivalent pairs of species with concordant ornamentation. Some authors (e. g. POZZI, 1965) suppose that it is a secondary phenomenon produced by corrosion of the so-called punctate layer in *Punctaptychus*. However, KÄLIN & al. (1979) and also I state that it is not so, at least not in all cases.

The Lower Berriasian is still typified by a considerable diversity of *Punctaptychus*, the valves of which reach in most cases the size of 5 – 6 cm. Together with the punctaptychi and *L. beyrichi* subordinately also *L. rectecostatus*, *L. aplanatus aplanatus*, *L. a. latus* and *L. submortilleti* occur (Figs. II/1, 2, 4, 5). Later, in the upper part of Lower Berriasian punctaptychi with discordant costation of smaller size predominate. They belong e.g. to *P. cinctus* (Figs. I/5, 6). Near the boundary between the Lower and Upper Berriasian the occurrence of punctaptychi is strongly reduced, however, our last finding of *Punctaptychus* comes even from the Lower Valanginian (as the common occurrence with *Calpionellites darderi* proves). By the above given boundary some lamellaptychi of the older type, e.g. *L. elegans* (Fig. III/1), *L. cinctus* (Fig. II/7) disappear, and some new elements, e.g. *L. studeri, L. herthae* (Figs. II/6, 8, 9) and others occur.

The Lower Valanginian is typified by a considerable diversity of *L. mortilleti,* divisible into several subspecies *(L. m. mortilleti, L. m. noricus, L. m. radiatus)* – Figs. III/3–6. From these, more and more complicated types may be derived. They are characterised by juvenile costation the style which is typical for *L. mortilleti.* However, in this species the last ribs are more complicated: they can turn back to the apex in the terminal area as it is recognizable for example in the species *L. helveticus, L. stellariformis* (Fig. V/3, Fig. III/7), *L. lorioli* (Fig. V/2) and others.

In the Lower Valanginian also the first marked diversification in the group of *L. aplanatus* occurs from which e.g. *L. noricus, L. excavatus, L. bermudensis, L. trauthi* (Figs. IV/1, 3, 4, 7) and the oldest aptychi with angularly broken ribs are derived, as with *L. symphysocostatus,* and *L. retroflexus* (Figs. IV/2, 6).

Similar assemblages of aptychi partly survive, partly develop further around the Lower to Upper Valanginian boundary. Near the end of the Lower Valanginian, *L. symphysocostatus* disappears, *L. retroflexus* persists and new species such as *L. bicurvatus* and *L. beyrichodidayi* appear (Figs. V/4, 5). Rarely, the first specimens of *L. didayi* (Fig. V/8) may also occur.

In the (ammonite) Trinodosum Zone the last aptychi of the older type may be found, however, more often *L. beyrichodidayi* and *L. didayi* occur. *L. seranonis* appears as a new element (Figs. V/6, 7).

The Uppermost Valanginian (Callidiscus Zone) and the Lowermost Hauterivian yield the same aptychi: *L. didayi* and *L. seranonis* prevail, however, the latter is of index importance because of the abundance of occurrence. In the Uppermost Valanginian *L. retroflexus* occurs for the last time.

The late Lower Hauterivian (Loryi and Nodosoplicatum Zones) is significant for the further abundant occurrence of aptychi. However, only two species are present: *L. didayi* and *L. seranonis*. In the upper part of the Lower Hauterivian also *L. atlanticus* (Fig. V/9) may rarely be found. The last occurrences of the aptychi *L. didayi* and *L. seranonis* correspond to the end of the Lower Hauterivian (in accordance with GASIOROWSKI, 1962a). With respect to the fact that ammonites of the uppermost Lower Hauterivian are absent in the Czech and Slovak Carpathians, the presently cited aptychi represent the only macrofaunal elements making possible the demarcation the Lower to Upper Hauterivian boundary.

Sediments of the Upper Hauterivian are characterized only by aptychi with subangular to angular lamellae turning backwards to the apex. They belong to *L. filicostatus, L. cristobalensis* (Figs. VI/2-4) and to the more frequent group of *L. angulocostatus* (PETERS). The latter group is characterised by its marked variability in the angular lamellae, which is the basis for differentiating several subspecies. The range of *L. angulocostatus radiatus* (Figs. VI/5, 6) and *L. cristobalensis* terminates most probably already in the lower part of the Upper Hauterivian, while *L. angulocostatus angulocostatus, L. angulocostatus anguli-costatus* (Figs. VI/7, 8) as well as *L. filicostatus* extend up to the end of Hauterivian. The last lamellaptychi found in the Czech and Slovak Carpathians come from the top of the Angulicostata Zone.

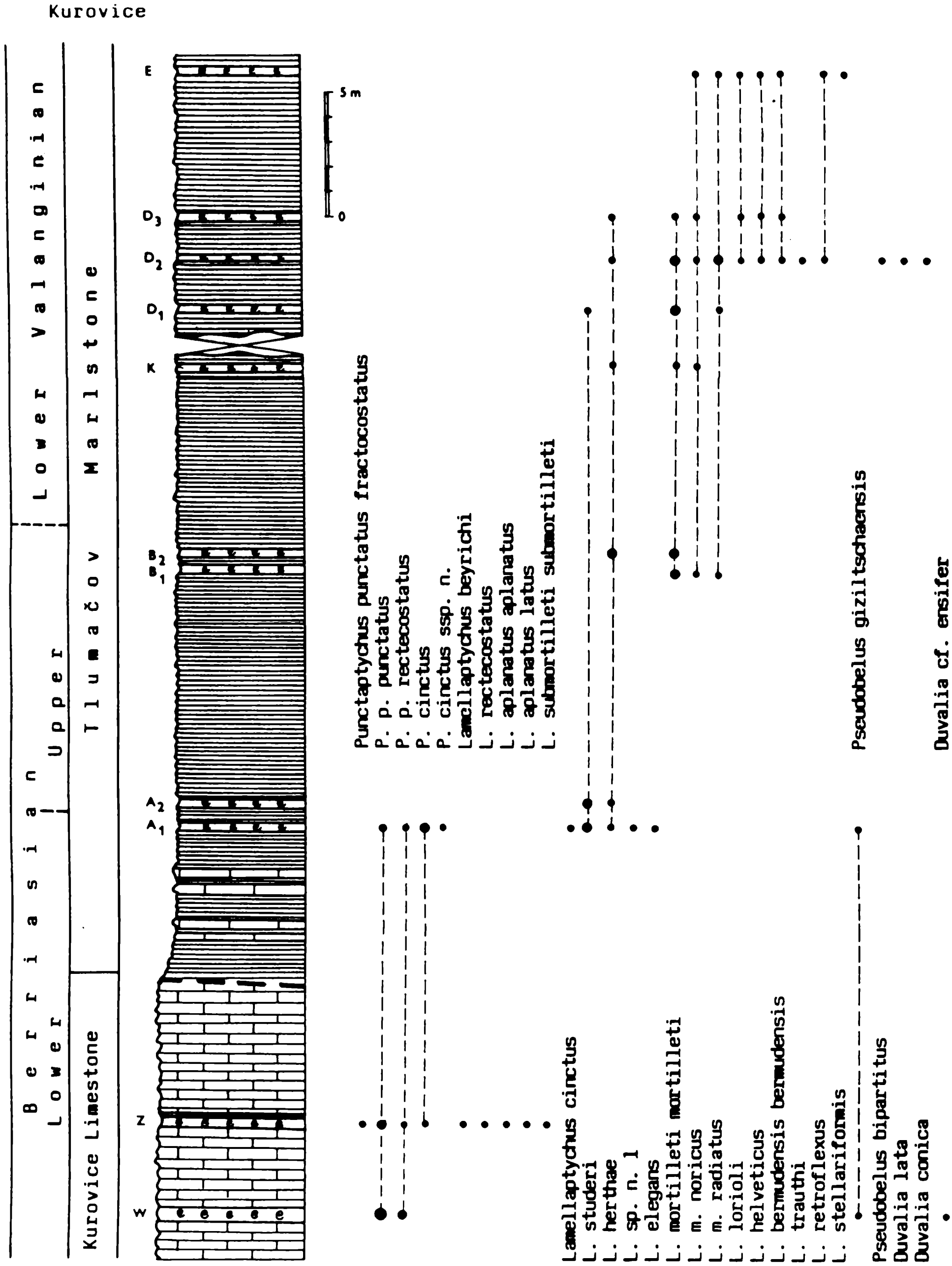

Fig. 3: Studied section of the Kurovice quarry, Magura Unit, Outer Carpathians.

Conclusions

GASIOROWSKI (1962a) first investigated the distribution of the aptychi in the Western Carpathians. For the Middle Jurassic to Lower Cretaceous he defined eight basic aptychi zones (designated with Roman numerals I–VIII), originally designated as horizons, and later subdivided into 21 subhorizons. DURAND DELGA & GASIOROWSKI (1970) re-evaluated the sequence and added some observations from the western part of the Mediterranean area.

The aptychi horizons determined by GASIOROWSKI follow the ammonite zones used in the early 1960ies. However, such zonal concepts do not correspond to stage and substage boundaries so that GASIOROWSKI's conclusions are in most cases redundant. On the other hand, GASIOROWSKI (1962a, b, 1985) differentiated (especially in the Upper Jurassic) various tethyan aptychi assemblages and defined three basic world-wide provinces, based on aptychi.

RENZ (1978, 1983 etc.) and RENZ & HABICHT (1985) reviewed the distribution and correlation of aptychi from the Tithonian and the Upper Hauterivian (and perhaps also from the Barremian) in the sediments of the Atlantic ocean (obtained in the framework of the DSDP international project) and of Swiss deep-water horizons, but these occurences could not be linked to ammonite zones. The abundance of aptychi in the sediments they studied is reflected in a great number of new species and subspecies.

The present results from investigating the Lower Cretaceous aptychi in the Czech and Slovak Carpathians represent the diversification scheme of Lower Cretaceous aptychi according to my knowledge and my ideas (Fig. 2). The ammonite zonation used respects the proposals from Digne (HOEDEMAEKER & BULOT, 1990). The left-hand side of the figures shows the morphological types of *Punctaptychus* not exceeding into the Lower Valanginian.

The most conspicuous development in the Lower Cretaceous can be observed in *Lamellaptychus*. Ammonites producing aptychi belonged – according to my conception – to two ammonoid groups, as is obvious from the different types of aptychi costation.

In the case of the main branch of development with *Lamellaptychus beyrichi* as the starting type, the ribs converge along the symphysal valve margin: in stratigraphically older representatives the ribs converge along its prevailing length, while in the younger representatives it is so in the shorter part. With the youngest aptychi (from the development point of view) angular costation predominates; the juvenile valve parts being only rarely preserved.

In the second branch of development, where the initial type seems to be *Lamellaptychus aplanatus,* the ribs pass coincidently or nearly coincidently with the valve contour. This tendency is seen at least in the juvenile ribs up to the extinction of the last representatives in this group at the Valanginian-Hauterivian boundary. At first the juvenile as well as adult ribs in this group cut the direct (symphysal) margin at an angle of more than 50°. The angle increases gradually up to 90° and more, as a result of which the ribs turn back to the apex. In the Lower Valanginian the ribs in some types are angularly broken close to the symphysal margin. In another partial branch of development the ribs are subsequently simply or bent twice. However, the present scheme of branches of development must be further defined and verified.

A conspicuous morphological diversity in costation of aptychi in a short time leads to a nomenclature that permits aptychi to be advantageously used as index fossils wherever they occur. They are found especially in sediment from which the aragonite shells of invertebrates were dissolved long ago, while the calcite valves of aptychi are still preserved, i. e. as especially in Lower Cretaceous deep-water sediments.

Acknowledgements

The author is much indebted to Mrs. K. MEZIHORÁKOVÁ for the quality of photographs made, to Mrs. B. Vavrušáková for preparing the figures, to Dr. M. WEBEROVÁ for translating the whole text into English. The author is also very grateful to the Alexander von Humboldt Foundation for the financial support to participate in the 4th International Cretaceous Symposium in Hamburg.

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Pl. I

Fig. 1: *Punctaptychus punctatus punctatus* (VOLTZ), × 1. Spec. Ku-jl/8. Kurovice Limestone, Lower Berriasian.

Fig. 2: *Punctaptychus punctatus fractocostatus* TRAUTH, × 1. Spec. Ku-jl/14. Kurovice Limestone, Lower Berriasian.

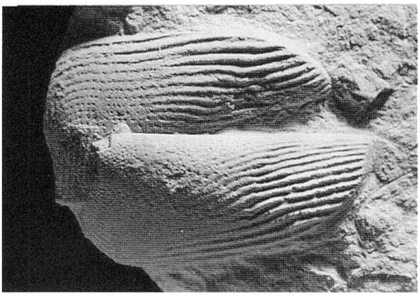
Fig. 3: *Punctaptychus punctatus rectecostatus* CUZZI, × 1. Spec. Ku-A1/21. Tlumačov Marls, Upper Berriasian.

Fig. 4: *Punctaptychus* sp. 1, × 2. Spec. Ku-jl/1. Kurovice Limestone, Lower Berriasian.

Fig. 5, 6: *Punctaptychus cinctus* TRAUTH, × 2. Spec. Ku-A1/2 and Ku-A1/23. Tlumačov Marls, Upper Berriasian.

Fig. 7, 8: *Punctaptychus* cf. *cinctus* TRAUTH, × 2. 7 – spec. Ku-A1/6. Tlumačov Marls, Upper Berriasian, 8 – spec. Ku-jl/2. Kurovice Limestone, Lower Berriasian.

All specimens come from the Kurovice quarry, Magura Unit, Outer Carpathians.



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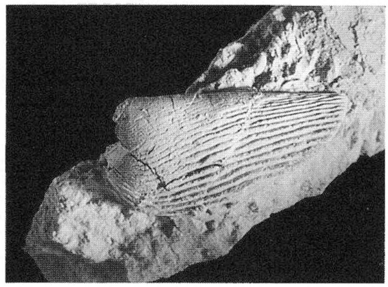

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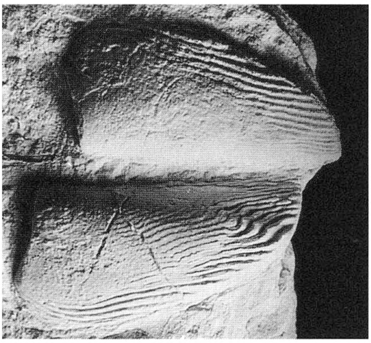

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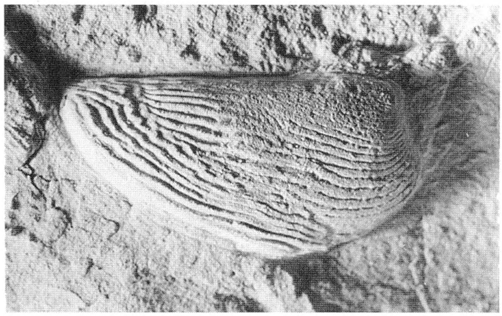

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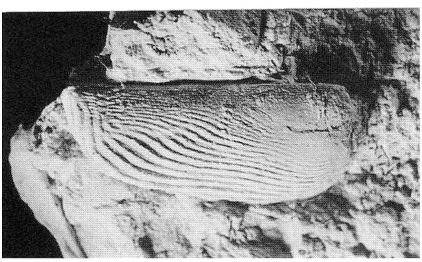

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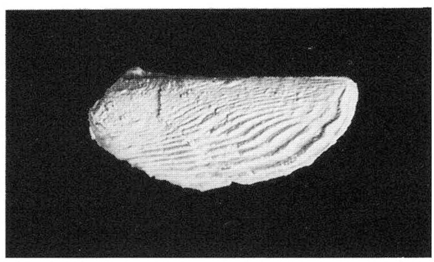

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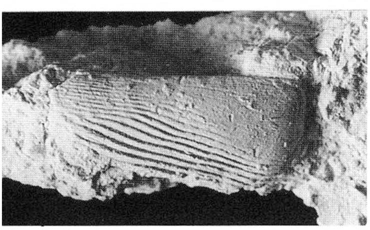

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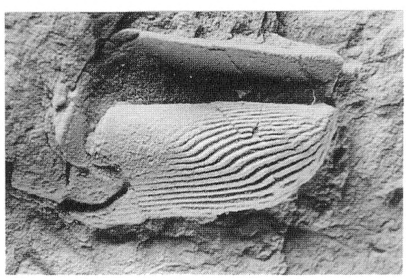

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Pl. II

Fig. 1: *Lamellaptychus rectecostatus* (PETERS), × 1. Spec. Ku-21. Kurovice Limestone, Lower Berriasian.

Fig. 2: *Lamellaptychus submortilleti* TRAUTH, × 1,5. Spec. Ku-jl/13. Kurovice Limestone, Lower Berriasian.

Fig. 3: *Lamellaptychus beyrichi* (OPPEL), × 1. Spec. Ku-35. Kurovice Limestone, Lower Berriasian.

Fig. 4: *Lamellaptychus aplanatus latus* TRAUTH, × 2. Spec. Ku-jl/3. Kurovice Limestone, Lower Berriasian.

Fig. 5: *Lamellaptychus aplanatus aplanatus* (PETERS), × 2. Spec. Ku-jl/15. Kurovice Limestone, Lower Berriasian.

Fig. 6: *Lamellaptychus herthae* (WINKLER), × 2. Spec. Ku-B2/1. Tlumačov Marls, Upper Berriasian.

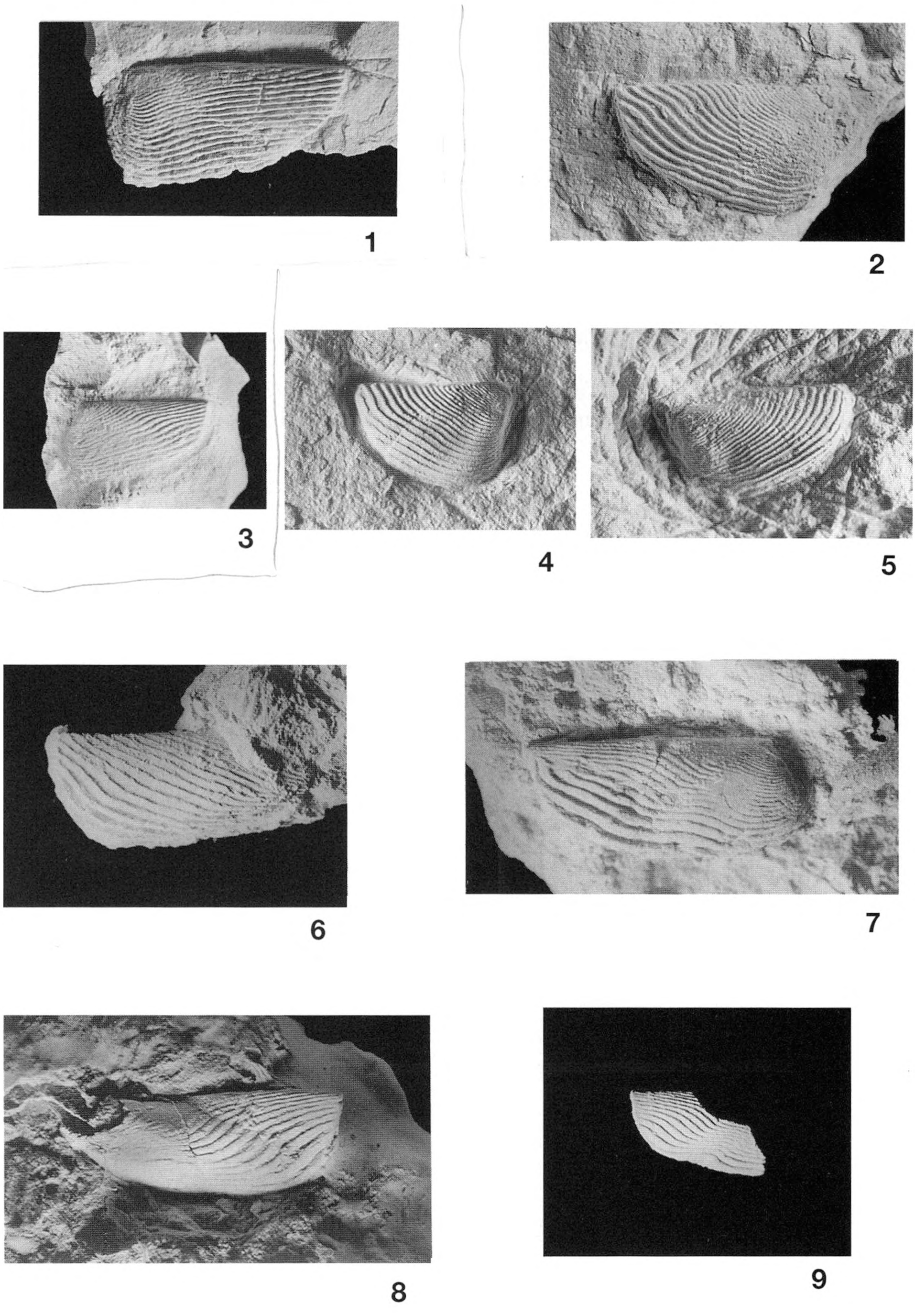
Fig. 7: *Lamellaptychus cinctus* TURCULET, × 3. Spec. Ku-A1/3. Tlumačov Marls, Upper Berriasian.

Fig. 8: *Lamellaptychus studeri* (OOSTER), × 2. Spec. Ku-A1/5. Tlumačov Marls, Upper Berriasian.

Fig. 9: *Lamellaptychus studeri* (OOSTER), × 2. Spec. HL-1. Těšín Limestone, Upper Berriasian.

Specimens in Fig. 1-8 come from the Kurovice quarry (Magura Unit), spec. in Fig. 9 from the Horní Líštná quarry, Silesian Unit, Outer Carpathians.

Pl. II



Pl. III

Fig. 1: *Lamellaptychus elegans* RENZ, × 2. Spec. Ku-A1/29. Upper Berriasian.

Fig. 2: *Lamellaptychus* sp. 1, × 2. Spec. Ku-A1/1. Upper Berriasian.

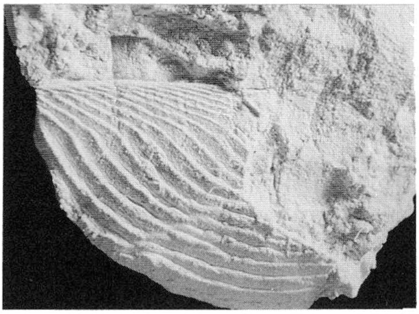
Fig. 3, 4: *Lamellaptychus mortilleti mortilleti* (PICTET & LORIOL), × 2. 3 – spec. Ku-D3/1992, 4 – spec. Ku-K2/1. Lower Valanginian.

Fig. 5: *Lamellaptychus mortilleti noricus* TRAUTH, × 2. Spec. Ku-D2/24. Lower Valanginian.

Fig. 6: *Lamellaptychus mortilleti radiatus* STEFANOV, × 2. Spec. Ku-D2/4. Lower Valanginian.

Fig. 7: *Lamellaptychus stellariformis* RENZ, x 3. Spec. Ku-E/2. Lower Valanginian.

All specimens come from the Kurovice quarry, Tlumačov Marls (Magura Zone).



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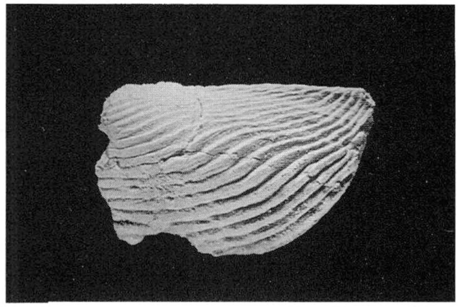

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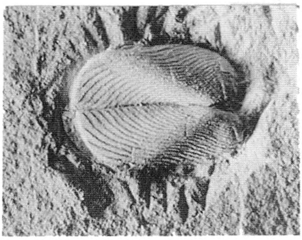

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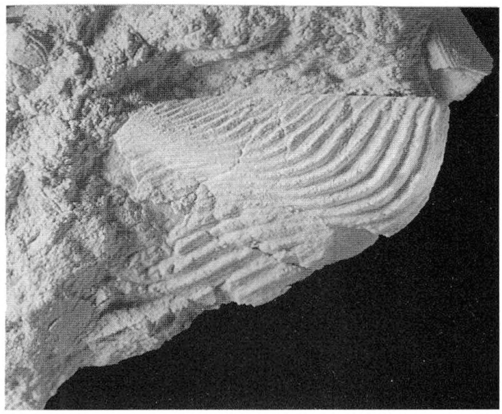

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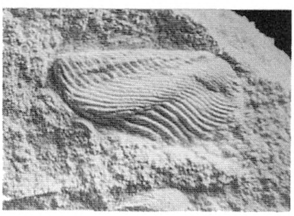

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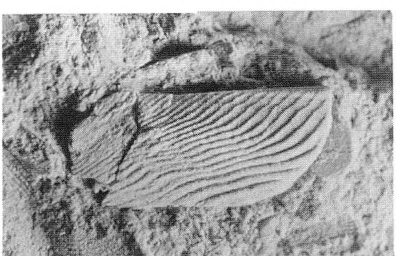

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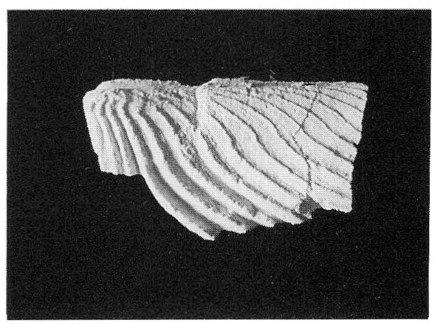

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Pl. IV

Fig. 1: *Lamellaptychus noricus* (WINKLER), × 2. Spec. BK 12-2/62. Butkov quarry, Ladce Formation, Upper Valanginian.

Fig. 2: *Lamellaptychus symphysocostatus* TRAUTH, × 2. Spec. BK 8-570/5. Butkov quarry, Ladce Formation, Lower Valanginian. Manín Unit, Central Carpathians.

Fig. 3: *Lamellaptychus excavatus* TRAUTH, × 2. Spec. BRD-192/3. Rudinka quarry, Pieniny Limestone, Upper Valanginian. Pieniny Klippen Belt, Outer Carpathians.

Fig. 4: *Lamellaptychus bermudensis* RENZ, × 2. Spec. Ku-D3/4. Lower Valanginian.

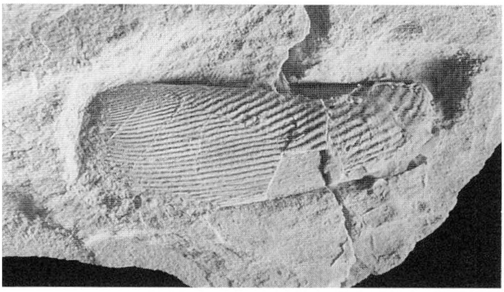
Fig. 5: *Lamellaptychus* sp. 2, × 2. Spec. Ku-D2/35. Lower Valanginian.

Fig. 6: *Lamellaptychus retroflexus* TRAUTH, × 2. Spec. Ku-D2/2. Lower Valanginian.

Fig. 7: *Lamellaptychus trauthi* RENZ & HABICHT, × 2. Spec. Ku-D2/6. Lower Valanginian.

Fig. 8: *Lamellaptychus* cf. *lombardicus* RENZ & HABICHT, × 2. Spec. Ku-D3/19. Lower Valanginian.

All specimens (excl. Fig. 1–3) come from the Kurovice quarry, Tlumačov Marls (Magura Unit, Outer Carpathians).



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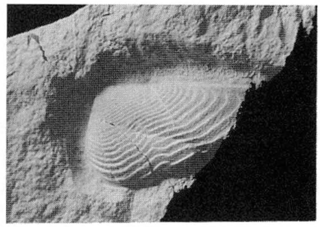

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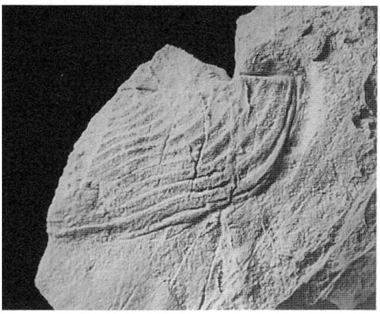

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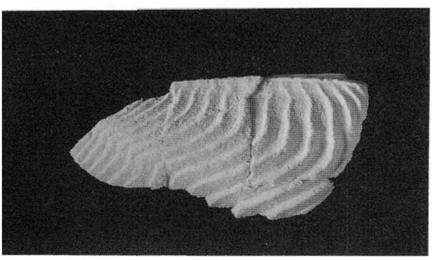

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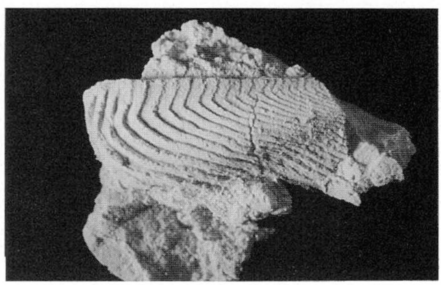

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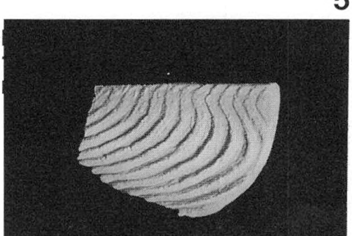

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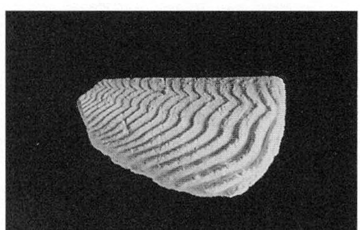

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Pl. V

Fig. 1: *Lamellaptychus mendrisiensis* RENZ & HABICHT, × 2. Spec. BK 8-505/10. Butkov quarry, Ladce Formation, Upper Valanginian. Manín Unit, Central Carpathians.

Fig. 2: *Lamellaptychus lorioli* RENZ, × 2. Spec. Ku-C/1. Kurovice quarry, Tlumačov Marls, Lower Valanginian. Magura Unit, Outer Carpathians.

Fig. 3: *Lamellaptychus helveticus* RENZ & HABICHT, × 2. Ex. Ku-D2/7 (the same locality as Fig. 2).

Fig. 4: *Lamellaptychus beyrichodidayi* TRAUTH, × 2. Spec. BK 5-300/2 (the same locality as Fig. 1).

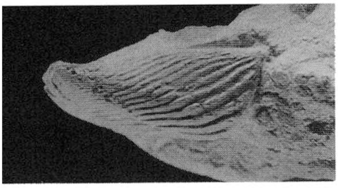
Fig. 5: *Lamellaptychus bicurvatus* RENZ & HABICHT, × 2. Spec. BK 6-270/2. Butkov quarry, Ladce Formation, Upper Valanginian. Manín Unit, Central Carpathians.

Fig. 6: *Lamellaptychus seranonis fractocostatus* TRAUTH, × 1. Spec. BK V – 7E/4. Butkov quarry, Mráznica Formation, Lower Hauterivian, Manín Unit, Central Carpathians.

Fig. 7: *Lamellaptychus seranonis seranonis* (COQUAND), × 1. Spec. BK 5-270/12 (the same locality as Fig. 6).

Fig. 8: *Lamellaptychus didayi* (COQUAND), × 1. Spec. BK 8-430/1 (the same locality as Fig. 6).

Fig. 9: *Lamellaptychus atlanticus* (HENNIG), × 2. Spec. BK 8-450/2 (the same locality as Fig. 6).



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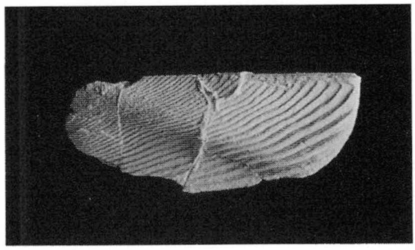

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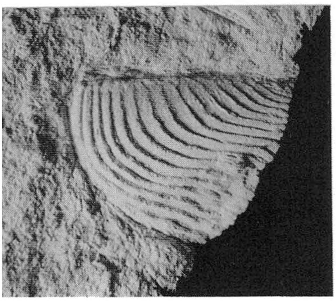

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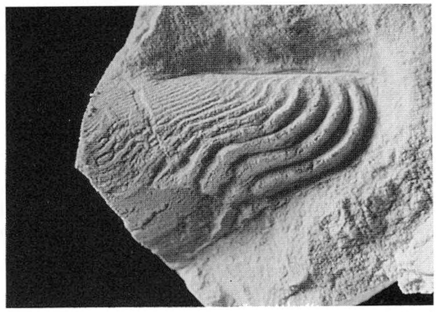

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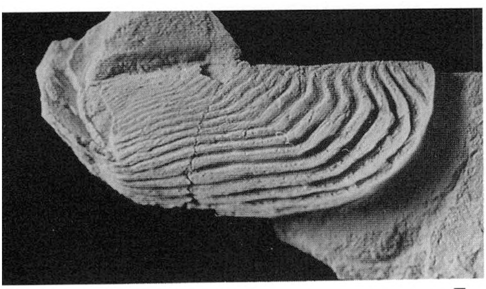

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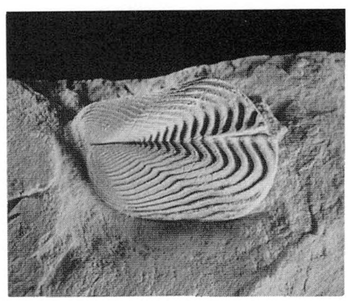

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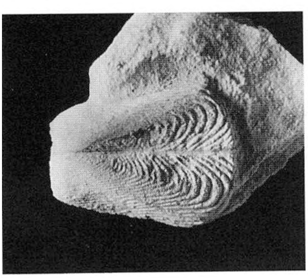

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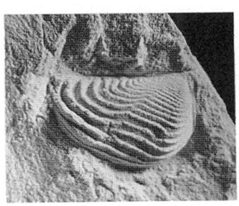

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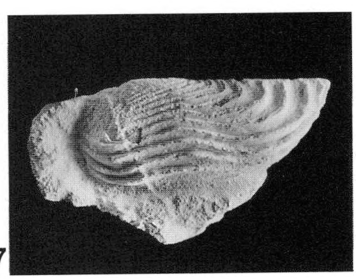

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Pl. VI

Fig. 1: *Lamellaptychus seranonis* ssp. 1, × 2. Spec. ŠT-3/27. Clay pit near Štramberk, Têšín-Hradištê Formation. Lower Hauterivian. Silesian Unit, Outer Carpathians.

Fig. 2: *Lamellaptychus cristobalensis* (O'CONNEL), × 1,5. Spec. LL IV - 10/11. Polomec quarry.

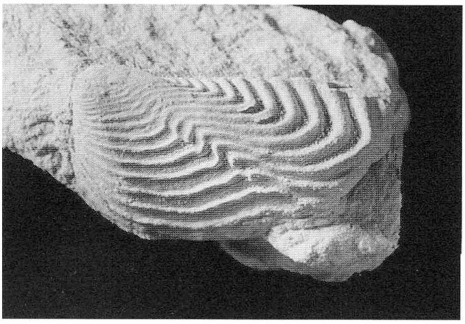
Fig. 3, 4: *Lamellaptychus filicostatus* STEFANOV. 3 - spec. LL V-250/A, × 1. Polomec quarry; 4 - spec. LS 1-87/1, x ×. Outcrop in the village Lietavská Svinná.

Fig. 5, 6: *Lamellaptychus angulocostatus radiatus* TRAUTH, x 1. Spec. LL IV-270/8 (the same specimen at different illumination). Polomec quarry.

Fig. 7: *Lamellaptychus angulocostatus angulocostatus* (PETERS), × 2. Spec. PL II - 3/2. Laz quarry.

Fig. 8: *Lamellaptychus angulocostatus angulicostatus* (PICTET & LORIOL), × 1. Spec. LL V-250/5. Polomec quarry.

All specimens come (excl. Fig. 1) from the Mráznica Formation, Upper Hauterivian. Krížna Nappe, Central Carpathians. Photo K. MEZIHORÁKOVÁ, University of Ostrava. The specimens were whitened with ammonium chloride prior photographing. The material is deposited at the Department of Geology, Mineralogy and Geochemistry, Mining University in Ostrava.



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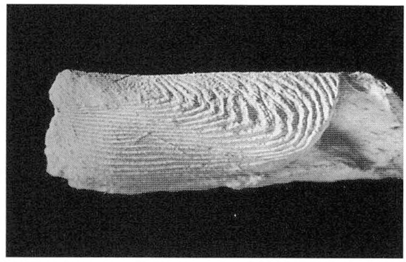

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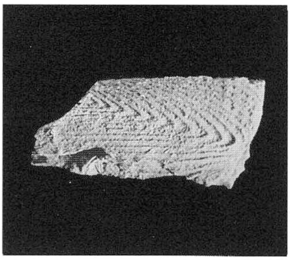

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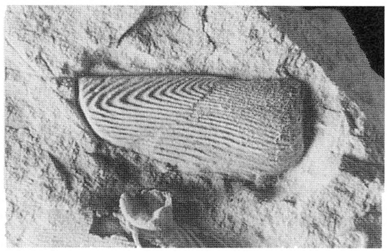

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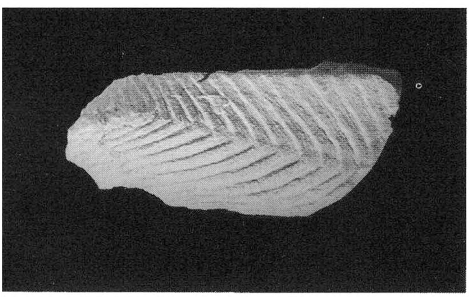

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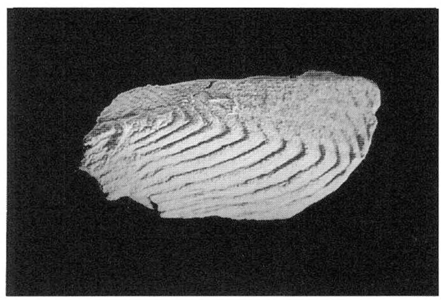

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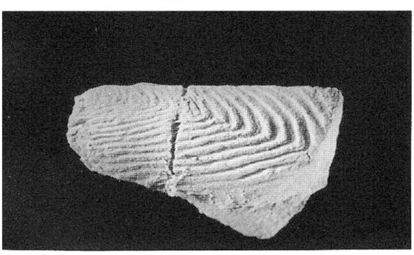

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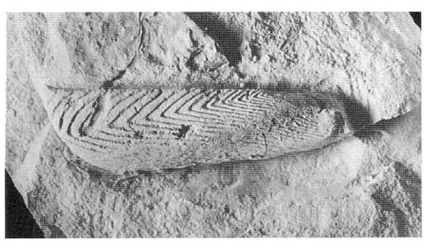

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