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# Worm-like fossils (Palaeoscolecida; ?Chaetognatha) from the Lower Ordovician of Bohemia

## Vermiformní fosilie (Palaeoscolecida; ?Chaetognatha) ze spodního ordoviku Čech

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Abstract: Palaeoscolecidans (?*Annelida*) are known from the Cambrian to the Silurian; in Bohemia they occur from the Arenigian to the Dobrotivian only. The state of preservation of specimens from Bohemia enables detailed description of cuticle morphology, ultrastructure, and discussion of the systematic position of palaeoscolecidans. Their locomotion and mode of life is discussed, too. The family *Plasmuscolecidae*, and the genera *Bohemoscolex*, *Gamascolex*, and *Plasmuscolex* are erected. Five new species together with three indeterminable specimens are described in the systematic part. In addition, the description of a new genus *Titerina* (*T. rokycanensis* sp. n.) is given; this belongs probably to *Chaetognatha*.

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### Introduction

The palaeoscolecidans are a characteristic group of annelid-like metazoans with uniform body plan: their bodies are composed of several hundreds of identical, usually papillate segments without distinct traces of cephalization, body appendages, chaetae, and with rigid, resistant cuticle. They range from the Early Cambrian to the Late Silurian, and judging from their rarity in fossil records, they were uncommon elements in benthic marine assemblages during the Lower Paleozoic age.

The finds of palaeoscolecidans have been reported under the generic names *Palaeoscolex* and *Protoscolex* from the Cambrian (CONWAY-MORRIS 1977, CONWAY-MORRIS - ROBISON 1986, GLAESSNER 1979, ROBISON 1969), Tremadocian (OWENS - FORTEY - COPE - RUSHTON - BASSETT 1982, WHITTARD 1953), Middle—Upper Ordovician (CONWAY-MORRIS - PICKERILL - HARLAND 1982, RUEDEMANN 1925, ULRICH 1878), and Silurian (BATHER 1920, MIKULIC - BRIGGS - KLUESSENDORF 1985). In Bohemia, palaeoscolecidans range from the Arenigian (Klabava

Formation) to the Dobrotivian (Dobrotivá Formation). Apart from "*Palaeoscolex*", three distinct new genera are present in our material. Additional material suggests further palaescolecidan species, but the material is not sufficient for determination and description of new taxons.

In the present paper we describe a minute, worm-like fossil of unclear affinity (recalling *Chaetognatha*), which occurs in Arenigian rocks, too.

Depositories: The material is deposited in the collections of the Geological Survey, Prague (GS-MM, GS-p), collections of the National Museum, Prague (NM-L) and collections of the District Museum of Dr. B. Horák, Rokycany (OMR).

Acknowledgements: We are grateful to S. Conway-Morris (University of Cambridge, England) for useful discussion and loan of information about palaeoscolecidans; J. R. Prokop (National Museum, Prague) for the privilege to examine the collections; J. Kulich (Charles University, Prague) for making SEM photos; Z. Kotrba (Geological Survey, Prague) for EMA investigation; M. Kunst (Charles University, Prague) for making the photos of *Titerina.*

## Material and methods

The hitherto reported finds of palaeoscolecidans (Whittard 1953 a.o.) come from shales or siltstones. Palaeoscolecidan remains are mostly strongly flattened and folded, showing overall shape of bodies, fine details (papillae, pustules), and more rarely internal structures (jaws, gut). An essential part of Bohemian specimens comes from grey-green, dark-grey or reddish clayey or micaceous shales, and their remains are deformed in the same way, too. Several specimens from the Dobrotivá Formation have been obtained from siliceous nodules, and in spite of the wrinkling of their bodies, they are preserved as internal and external moulds, occasionally with cylindrical shape of the trunk preserved. These two different modes of preservation enable recognition of cuticle deformation during the compression. This is an important circumstance for investigation of the species available as flattened imprints only. All specimens of palaeoscolecidans are preserved as moulds or imprints of cuticle; the soft parts of the body are preserved very scarcely. The cuticle was undoubtedly more resistant than other parts of the body, and it is not excluded, that cuticle may be moulded as in recent priapulids (Shapeero 1962), or that the cuticle may be loosened from the rest of body wall by sudden contraction of body wall or decay (compare Conway-Morris 1977, p. 11).

The overall rarity of palaeoscolecidans influenced our methods. Apart from natural imprints and remains of original cuticle substance, latex casts have been used for SEM investigation.

## List of specimens

*"Palaeoscolex" tenensis* sp. n.: Arenigian, Klabava Formation, 4 metres above base of formation.

GS-MM 199: minute fragment of trunk, preserved in wrinkled, flattened position in reddish shale; locality Těně (text-fig. 1/1).

*Gamascolex herodes* gen. et sp. n.: Dobrotivian, Dobrotivá Formation.

NM-L 24634: slightly deformed trunk, preserved as internal and external moulds in siliceous nodule, holotype; locality Malé Přilepy (text-fig. 1/8).

NM-L 24636: short part of slightly deformed trunk, preserved as internal and external mould in siliceous nodule; locality Malé Přilepy (text-fig. 1/8).

NM-L 24637: short part of strongly wrinkled trunk, preserved as internal and external moulds in siliceous nodule; locality Malé Přilepy (text-fig. 1/8).

NM-L 24638: short part of slightly deformed trunk, preserved as internal and external moulds in siliceous nodule; locality Šárka (text-fig. 1/9).

NM – without number: short, poorly preserved part of trunk in siderite oolitic ore; locality "Veronika" mine near Kařízek (text-fig. 1/10).

GS-MM 118: part of trunk of large, slightly flattened specimen, preserved as internal and external moulds in siliceous nodule; locality Malé Přilepy (text-fig. 1/8).

GS-p 5050: almost complete specimen, with one terminal preserved, composed of more than 250 segments. Trunk preserved as internal and external moulds, partly flattened, in siliceous nodule; locality Malé Přilepy (text-fig. 1/8).

OMR 11799: flattened part of large trunk, partly preserved as imprint in micaceous shale, partly as internal and external moulds in siliceous nodule; locality Hůrka hill near Starý Plzenec (text-fig. 1/12).

*Bohemoscolex holubi* gen. et sp. n.: Arenigian, Klabava Formation, Corymbograptus v-similis Biozone.

OMR 9595: flattened part of trunk with coiled terminal part in clayey shale; locality Rokycany – hospital (text-fig. 1/2).

*Plasmuscolex klabavensis* gen. et sp. n.: Arenigian, Klabava Formation, Tetragraptus abbreviatus Biozone.

OMR 18726: long part of trunk without terminals, preserved in flattened position in clayey shale, holotype; locality Klabava – Starý hrad (text-fig. 1/5).

OMR 18198: almost complete minute specimen, preserved in flattened position in clayey shale; locality Klabava – Starý hrad (text-fig. 1/5).

OMR 18727: fragmental decayed part of trunk, preserved in flattened position in clayey shale; locality Klabava – Starý hrad (text-fig. 1/5).

OMR 10500: almost complete specimen of minute size, preserved in flattened position in clayey shale. Trace of burrow activity preserved; locality Rokycany – Stráň (quarry) (text-fig. 1/6).

*Plasmuscolex nero* gen. et sp. n.: Dobrotivian, Dobrotivá Formation.

NM-L 24635: slightly deformed, contracted part of trunk, preserved as internal and external moulds in siliceous nodule; locality Šárka (text-fig. 1/9)

OMR 11679: slightly flattened part of trunk and terminal, preserved as internal and external moulds in micaceous shale, holotype; locality Sutice hill near Starý Plzenec (text-fig. 1/11).

*Palaeoscolecida* gen. indet. A: Arenigian, Klabava Formation, Tetragraptus abbreviatus Biozone.

OMR 18171: short fragment of very small, slightly flattened trunk in clayey shale; locality Klabava – Starý hrad (text-fig. 1/5).

*Palaeoscolecida* gen. indet. B: Arenigian, Klabava Formation, Holograptus tardibrachiatus Biozone.

OMR 18751: poorly preserved, strongly flattened part of trunk in clayey shale; locality Rokycany – Valcha (text-fig. 1/3).

*Palaeoscolecida* gen. indet. C: Llanvirnian, Šárka Formation, Corymbograptus retroflexus Biozone.

OMR 9055: poorly preserved part of trunk in siliceous nodule; locality Mýto (text-fig. 1/7).

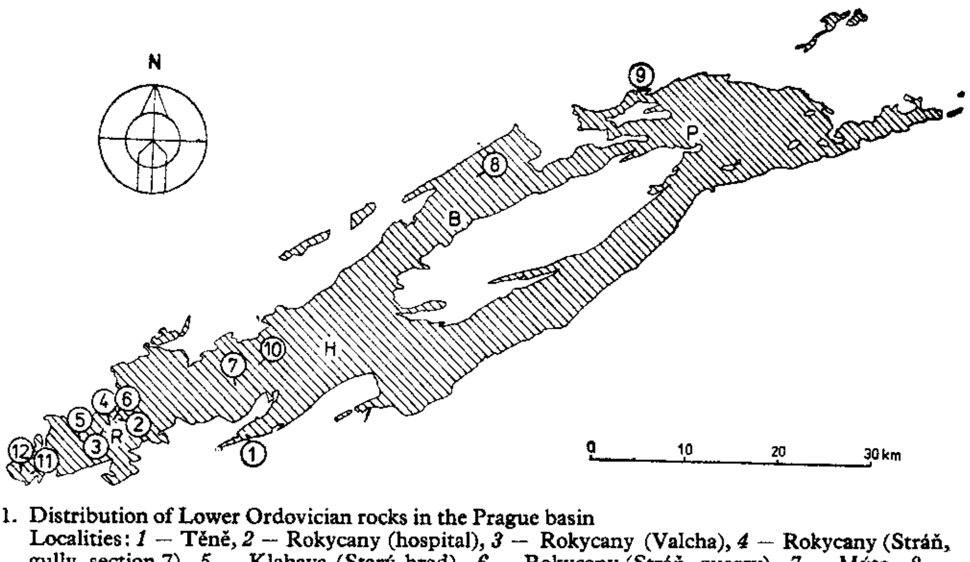
*Titerina rokycanensis* gen. et sp. n.: Arenigian, Klabava Formation, Holograptus tardibrachiatus Biozone.

OMR 15334A-C: complete (A) and fragmental (B, C) specimens, preserved in flattened position in clayey shale; locality Rokycany — Stráň (gully, section 7) (text-fig. 1/4).

Table 1

Stratigraphic occurrence of Bohemian palaeoscolecidans and *Titerina*

| Series | Formation | Graptolite Biozone | Occurrence | |
|---|---|---|---|---|
| **DOBROTIV** | Dobrotivá | | □Gamascolex herodes | □Plasmuscolex nero |
| **LLANVIRN** | Šárka | Didymograptus clavulus | | |
| | | Corymbograptus retroflexus | □Palaeoscolecida C | |
| **ARENIG** | Klabava | Tetragraptus abbreviatus | □Palaeoscolecida A | ▯Plasmuscolex klabavensis |
| | | Holograptus tardibrachiatus | □Palaeoscolecida B | ■Titerina rokycanensis |
| | | Corymbograptus v-similis | □Bohemoscolex holubi<br>□"Palaeoscolex" tenensis | |



1. Distribution of Lower Ordovician rocks in the Prague basin
Localities: *1* — Těně, *2* — Rokycany (hospital), *3* — Rokycany (Valcha), *4* — Rokycany (Stráň, gully, section 7), *5* — Klabava (Starý hrad), *6* — Rokycany (Stráň, quarry), *7* — Mýto, *8* — Malé Přílepy, *9* — Šárka, *10* — Kařez (mine "Veronika"), *11* — Starý Plzenec (Sutice hill), *12* — Starý Plzenec (Hůrka hill); B — Beroun, H — Hořovice, P — Praha, R — Rokycany

## Terminology

Recent annelid terminology is applied to structures of palaeoscolecidans cuticle which seem to be homologic with cuticular structures of recent annelids. The terminology is the same as in Richards (1978). New terms are introduced where necessary.

**Central band**: Transverse band, with or without tubercles in mid-length of each segment.

**Dorsal (ventral)**: These terms are used in description sense only, they do not indicate the original orientation of animal anatomy.

**Epicuticular projections**: Minute, short, mound to papillae-like outgrowths, covering densely outer cuticular surface.

**Intersegmental furrow**: Deep, transversal cutting between two adjacent segments.

**Length of segment**: Distance between bottoms of two adjacent intersegmental furrows. At coiled specimens measured at mid-width of flattened body.

**Longitudinal ridge (furrow)**: Longitudinal, fine ridge (or suture) on dorsal and ventral outer cuticular surface.

**Segment**: Annulation on cuticle, anteriorly and posteriorly bordered by intersegmental furrows.

**Tubercles**: Circular to elongate, more or less distinctly bordered elevations, encircling in several (usually two) rows outer cuticular surface of each segment (= papillae in Whittard 1953).

**Tubercle band**: Transverse band along margin or at mid-length of each segment, bearing tubercles.

**Tubercle impression**: Strong to obscure impressions on inner cuticular surface, corresponding in arrangement to tubercles of outer cuticular surface.

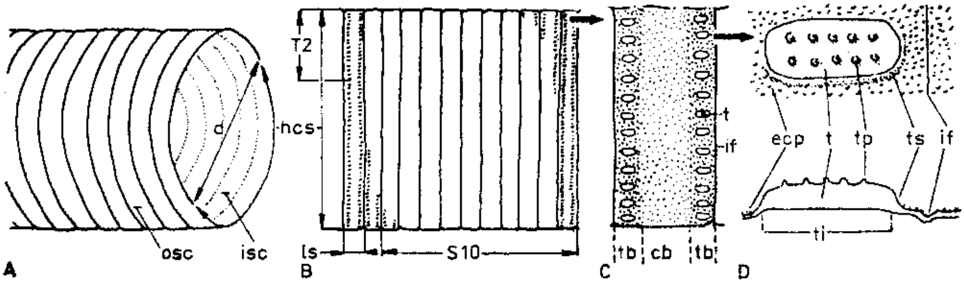
**Tubercle projections**: Minute, thorn-like outgrowths extending externally from the tops of tubercles.

**Tubercle slopes**: Slopes connecting top of tubercle with adjacent outer cuticular surface.

**hcs (cs)**: Half (total) circumference of segment, usually it is equal to the width of flattened specimen; diameter of body = $cs/\pi$.

**T2**: Number of tubercles per 2 mm at single tubercle band.

**S10**: Number of non-contracted segments per 10 mm.



2. Morphology of cuticle of palaeoscolecidans
*A* — undeformed cuticle, *B* — flattened cuticle, *C* — structures of single segment, *D* — tubercle with adjacent surface of cuticle (outer surface and lateral view)
*cb* — central band, *d* — diameter of body, *ecp* — epicuticular projections, *hcs* — half circumference of segment, *if* — intersegmental furrow, *isc* — inner surface of cuticle, *ls* — length of segment, *osc* — outer surface of cuticle, *t* — tubercle, *tb* — tubercle band, *ti* — tubercle impression, *tp* — tubercle projections, *ts* — tubercle slope, S10 — number of non-contracted segments per 10 mm, T2 — number of tubercles per 2 mm

## Morphology of cuticle

The excellent preservation of cuticular structures of *Gamascolex* and *Plasmuscolex* enabled reconstruction of palaeoscolecidan cuticular structures, their interpretation, and comparison with cuticular structures of recent annelids. We consider, that cuticular structures, especially shape and spacing of tubercles, are significant features of palaeoscolecidans, applicable for erection of new taxons. The variability of corresponding structures within single species is very low and it is only slightly influenced by the absolute size of specimen.

### *External structures of cuticle*

Epicuticular projections: The entire outer cuticular surfaces of *Gamascolex* and *Plasmuscolex*, apart from tubercles, are densely covered by fine outgrowths (= epicuticular projections). In *Gamascolex*, they are subequal in size (7—10 μm), circular to almost rectangular in outline. Epicuticular projections show no regular arrangement in central band, but they are arranged in irregular longitudinal rows between two adjacent tubercles at tubercle bands at dorsal side (pl. V, fig. 4). In areas adjacent to intersegmental furrow, the epicuticular projections are arranged in 12 to 16 transversal rows, they are larger and nearly rectangular in outline (pl. V, fig. 4). The bottoms of intersegmental furrows are covered by epicuticular projections of the same shape, too (pl. IV, fig. 5). The ventral side of the cuticle in *Gamascolex* shows slightly different spacing of epicuticular projections in comparison with the dorsal one, described above. The transversal rows of epicuticular projections bounding intersegmental furrows are less distinct. In tubercle bands, the areas with alternating rows of unequally large projections appear. There are large projections (15—20 μm) surrounded by smaller ones (5—7 μm; pl. VI, fig. 1). Judging from negative imprints of outer cuticular surface, the epicuticular projections are mound to papillae-like in shape, less than 10 μm high.

Epicuticular projections in *Plasmuscolex* are papillae-like in shape, less than 5 μm in diameter, uniform in size, arranged in oblique rows (pl. IX, fig. 5). This type of epicuticular projections appears at the bottoms of notches between two adjacent tubercles in tubercle bands. The second type of epicuticular projections are smaller, less regularly spaced and densely crowded outgrowths in central bands (pl. IX, fig. 6; pl. XI, figs. 1, 2). Additional Bohemian palaeoscolecidans show similar, often very complicated structures in outer cuticular surface (pl. XV).

The two size categories of epicuticular projections and their spacing (larger along segmental margins, smaller in central bands) are typical palaeoscolecidan features. The similar ornamentation patterns have been observed at palaeoscolecidans by WHITTARD (1953), ROBISON (1969), and CONWAY-MORRIS - ROBISON (1986), too. In a shape and arrangement, the epicuticular projections of palaeoscolecidans recall epicuticular projections or microvilli of recent annelids (RICHARDS 1978).

Tubercles: Tubercles are variably developed large outgrowths or elevations, forming two, exceptionally one transversal bands on each segment. Stage of tubercle complexity differs in each genus.

*Plasmuscolex* possesses simple tubercles. Its tubercles are strong, longitudinally elliptical to pear-shaped steep elevations, with indistinct boundaries with the rest of the cuticular surface (pl. IX, figs. 4–6; pl. XI). Tubercle projections are very similar in the shape and spacing to epicuticular projections, differing only in having larger size, and they cover entire tubercle surface.

*Gamascolex* has two types of tubercles. The dorsal type tubercles are formed by moderately elevated platforms, longitudinally elliptical to nearly circular, 70–250 μm long (pl. V, figs. 3, 4; pl. VI, fig. 2; pl. IV, fig. 4). Their width is nearly uniform. The length of tubercles depends on their position on the body; the longest tubercles are located on dorsal side, whereas lateral and ventrolateral ones are shorter, attaining nearly circular outline. Tubercles in central band on ventral side of *Gamascolex* are conical in shape, with circular outlines, and are uniform in size (pl. IV, figs. 1, 2). Tops of all tubercles (dorsal and ventral) are smooth, without epicuticular projections, but bear two longitudinal rows of tubercle projections. The total number of tubercle projections depends on the size of the tubercle and ranges from 4 to 14.

Tubercles of *Palaeoscolex* were described by WHITTARD (1953). On the whole they are similar to tubercles of *Gamascolex*. "*Palaeoscolex*" *tenensis*, although poorly known, shows another type of tubercles. They are concave externally, with scallop-shaped or spinned margins and with undercut margins; their outline is longitudinally elliptical. Indeterminable palaeoscolecidans and *Bohemoscolex* indicate that tubercles are prominent, highly differentiated, but probably unnecessary structure of palaeoscolecidans.

Tubercle projections have been interpreted as bases of minute chaetae (WHITTARD 1953); this assumption has been discussed by CONWAY-MORRIS - ROBISON (1986). In recent annelids, the chaetae originate in epidermal follicles and penetrate the cuticle (STEPHENSON 1930). We suppose that tubercle projections did not house the chaetae due to their compact structure built of cuticular material, and their spacing. Tubercle projections are in contracted segments in opposite position; therefore, the suggestion that they bear the chaetae is hardly acceptable. Tubercles were more probably some sense organs. They externally recall wart-like structures serving as secretory cells openings in some priapulids (HAMMOND 1970).

Longitudinal ridge: Longitudinal ridge or furrow shows a very fine structure on outer cuticular surface. The ridge is developed both on dorsal and ventral sides, and the body along the ridge is bilaterally symmetrical. In *Bohemoscolex* the ridge is substitued by a furrow. Longitudinal ridge was observed in *Gamascolex* and *Plasmuscolex*, but undoubtedly it was present in other palaeoscolecidans, too (pl. IV, figs. 1, 2; pl. XIV, fig. 3).

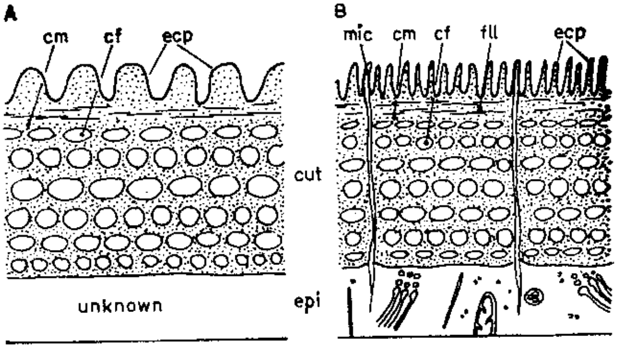
Table 2

Comparative data of Bohemian (A) and foreign (B) palaeoscolecidans

| species | length of fragment (in mm) | maximum of hcs (in mm) | S10 | T2 | tubercles at single segment | shape of tubercles |
|---|---|---|---|---|---|---|
| A | | | | | | |
| "*Palaeoscolex*" *tenensis*<br>specimen GS-MM 199 | 5 | 0.7 | 50 | 50—70 | 40—50 × 2 | elongate |
| *Gamascolex herodes*<br>specimen GS-p 5050 | 80 | 8 | 23—25 | 15—16 | 100—120 × 2 | dorsal elongate<br>ventral circular |
| GS-MM 118 | about 30 | 13.0 | 16—18 | 15—17 | 100—115 × 2 | ditto |
| NM-L 24634 | 22 | 9.5 | 19—22 | 14—17 | 90—120 × 2 | ditto |
| OMR 11799 | 28 | 14.5 | 9—10 | 11—15 | undeterminable | ditto |
| *Plasmuscolex klabavensis*<br>specimen OMR 18198 | 9.4 | 0.5 | 275 | 130—140 | 72 × 2 | elongate pear-shaped |
| OMR 10500 | 28.7 | 1.9 | 76 | 33—40 | 62 × 2 | ditto |
| OMR 18726 | 58.0 | 3.5 | 22—25 | 15—18 | 58 × 2 | ditto |
| OMR 18727 | 28.5 | 3 3 | 27—30 | 15—17 | 58 × 2 | ditto |
| *Plasmuscolex nero*<br>specimen OMR 11679 | 35.0 | 4.0 | 22—23 | 13—15 | 55—60 × 2 | elongate elliptial |
| *Bohemoscolex holubi*<br>specimen OMR 9595 | about 6.0 | 11.0 | 16—18 | absent | absent | absent |
| B | | | | | | |
| *Palaeoscolex antiquus*<br>(Glaessner 1979) | — | about 13 | 6—20 | 9—12 | 60 × 1? | circular |
| *Palaeoscolex ratcliffei*<br>(Robison 1969) | 125 | 2—5 | 30—40 | 30—50 | 50—80 × 2 | circular |
| *Palaeoscolex* cf. *ratcliffei*<br>(Conway-Morris – Robison 1986) | 81 | 7 | 24 | 10 | 70 × 2 | circular |
| *Palaeoscolex piscatorum*<br>(Whittard 1953) | 49 | 1.5 | 80—100 | 50—60 | 60—80 × 2 | circular to slightly elongate |

### *Internal structures of cuticle*

The cross-lamellar structure is preserved in original cuticular substance of *Gamascolex*. The lamellae lie at an angle of 60° to one another and at 60° to the body axis (pl. VI, figs. 3, 4). Lamellae are subequal in size, 2 – 3 μm wide, several times repeating throughout the thickness of the cuticle, overlapping one another. The cross-lamellar structure is developed in the whole cuticle except for tubercles. Tubercles are built of amorphous material with no structure visible. Cross-lamellar structure recalls cross-lamellar arrangement of collagen fibres in the cuticle of recent annelids (Richards 1977). The angles contained by collagen fibres range from 45° (Farnesi 1975) to 90° (Stephenson 1930). In recent annelids, however, the fibres are much slender than those in palaeoscolecidans, they reach 0.3 – 0.5 μm in diameter only.



3. Sections through cuticle of palaeoscolecidans (*Gamascolex*), and recent annelids (*Branchiobdella*)
*A* – *Gamascolex herodes*, × 1800, *B* – *Branchiobdella pentodonta*, × 18 000
*cut* – cuticle, *epi* – epidermis, *cf* – collagen fibres, *cm* – cuticle matrix, *ecp* – epicuticular projections, *fll* – felt-like layer (epicuticle), *mic* – microvilli; *B* – according to Farnesi (1973)

The size difference between the palaeoscolecidan and recent annelid fibres is difficult to explain, since the thickness variability of collagen fibres in recent groups is very restricted. In spite of this difference we believe that both structures are identical.

### *Segmentation*

The question of segmental units is widely discussed by Conway-Morris - Robison (1986). They suggest that boundaries between segments lie between papillate bands, in the unarmed (= central) bands. However, the unarmed bands are covered by finer ornamentation only in comparison to the remaining segmental surface. The overall uniformity of palaeoscolecidan body plan suggests that segmental boundaries lie in mid-length. between two tubercle bands, and they are marked by deeply cut grooves (intersegmental furrows). The segmental deformations on the inner side of coiled specimens (pl. II, fig. 2) and the formation of transversal ridges in contracted segments are better explainable by presumed segment boundaries than by the opinion of CONWAY-MORRIS - ROBISON (1986). It should be emphasized, however, that outer segmentation (and/or annulation) of a cuticle does not necessarily reflect the internal metameric segmentation.

### Chemical composition of cuticle

The cuticle is fossilized by dark brown-grey material, which changes into light grey-blue due to the effects of weathering. The EMA investigation of unweathered *Gamascolex* and *Bohemoscolex* cuticles enables to estimate the chemical composition. The cuticle is composed of Ca, P, and traces of Fe, S, and Si (C omitted). P: Ca ratio ranges about 4:5, and is almost constant in all the measured sites. It is evident that the cuticle is fossilized by apatite or other phosphatic minerals (Ca:P ratio is as in apatite standard).

### Systematic position of palaeoscolecidans

The discussions about relationships of palaeoscolecidans have been given in papers of BATHER (1920), WHITTARD (1953), and more recently of CONWAY-MORRIS - ROBISON (1986).

Our recent knowledge of palaeoscolecidans is based almost entirely on their cuticle shape; other features (shape of the gut, jaws) possess only limited taxonomic value. Lack of information about soft parts of the animal (e.g. reproductive system) and about structures of body terminals makes our assumptions about palaeoscolecidans affinity tentative. The main palaeoscolecidan features are as follows:

1) Firm, rigid, against decay rather resistant cuticle. The cuticle of recent annelids, although thick in some groups (RICHARDS 1979), is probably less resistant in comparison with the cuticle of palaeoscolecidans. Palaeoscolecidans occur in the rocks with rich assemblage of skeletal animals. Although the cuticle of palaeoscolecidans is undoubtedly secondarily phosphatized, no soft-bodied or lightly skeletized animals are preserved in the same rocks, in spite of common bioturbation and presence of scolecodonts.

2) Internal cross-lamellar structure of the cuticle. Cross-lamellar structure of the cuticle observed at *Gamascolex* strongly resembles similar structures in the cuticle of recent annelids (RICHARDS 1977; RUTSCHKE 1970; STORCH - WELSCH 1970).

3) Absence of cephalization and parapodia, both common in polychaetes. Palaeoscolecidans share with oligochaetes poorly differentiated body terminals, but the latter exhibit some structures (e.g. clitellum) unknown in palaeoscolecidans.

4) Presence of jaws. Two specimen of *Palaeoscolex piscatorum* possess structures interpreted as the jaws (WHITTARD 1953). In our material no similar structure was

observed, but that was due to the limited number of body terminals. Presence of jaws may be a significant feature distinguishing palaeoscolecidans from oligochaetes (WHITTARD 1953; CONWAY-MORRIS - ROBISON 1986).

5) Absence of chaetae. No signs of chaetae are preserved on the material available. Tubercle projections, interpreted as chaetae bases (WHITTARD 1953), are probably of other origin. In the remaining cuticular surface, uneven structures interpreted as chaetae or chaetae epidermal follicles (pores, penetrations through the cuticle) are absent. It is evident that palaeoscolecidans are without large chaetae; tiny, hair-like chaetae and cilia lack potential for preservation and their traces in the cuticle may be very delicate. Thus, the question of tiny chaetae presence/absence remains open for future investigation.

6) Double bands of tubercles (or papillae) encircling each segment in majority of palaeoscolecidans are of arrangement unknown in any recent annelid groups. However, some taxons (*Bohemoscolex*) indicate that the body plan significantly deviates from the definition of palaeoscolecidans given by CONWAY-MORRIS - ROBISON (1986).

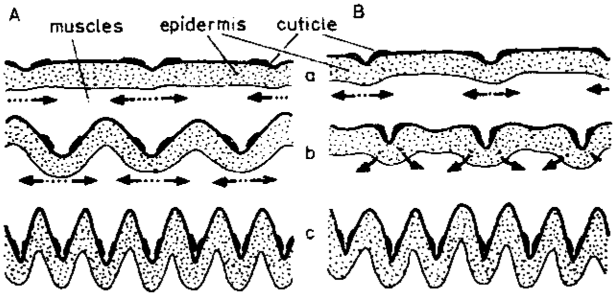
In external shape, the leeches (*Hirudinea*) are the closest of annelids to the palaeoscolecidans. Both groups share some features (presumed absence of chaetae, probably duplicated external annulation), but there are significant differences (absence of a sucker and higher number of segments in the latter). Similar external shape of the cuticle as that in palaeoscolecidans is developed in some nematodes (BOSTRÖM - GYDEMO 1983; WIDER - BARUŠ - TENORA 1978), and priapulids (CONWAY-MORRIS 1977; HAMMOND 1970; POR 1983).

## Locomotion

Recent annelids commonly used propagate waves for crawling or burrowing (TRUEMAN 1978). Each locomotion wave results in shortening — lengthening cycle, forming retrograde or direct waves. The limit to the changes of dimension and on that depending dimension of wave is met by the elastic limit of muscles and of the body wall (GRAY 1968).

Palaeoscolecidans have rigid, flexible but only slightly elastic cuticle covering the entire body surface. In a single segment, the thickness of the cuticle, and on this depending elasticity, varies. The central bands and areas flanking intersegmental furrows are built by a thinner cuticle in comparison with the cuticle thickness in tubercle bands. Accordingly, the former were more elastic than the latter. In *Gamascolex*, the dorsal and lateral parts of segments were able to form a fold along the central band and a deep groove along intersegmental furrow. Tubercle bands remain without change, becoming only steeply inclined (text-fig. 3; pl. IV, fig. 4). Ventral side of *Gamascolex*, bearing tubercle rows in central band of each segment, formed a set of extremely convex segments during contraction;

it exhibited no sharp transversal ridges in central bands of the segment (pl. IV, figs. 1, 2). In *Plasmuscolex*, non-contracted segments show gently elevated central bands with tubercle bands moderately inclined toward intersegmental furrows. At the beginning of contraction, tubercle bands are recurved, becoming steeply sloping towards the intersegmental furrows; central bands are without change or form a slightly concave transversal depression (text-fig. 4). Further contraction formed in central bands sharp, prominent ridges similar to the fold of *Gamascolex*. Tubercles in the tubercle bands of adjacent segments are nearly touching each other, forming tooth-like clinching in maximally contracted segments (pl. XI, fig. 2; pl. XII, fig. 5). In *Bohemoscolex* contracted segments have developed sharp ridges in the central bands.



4. Schema of contraction of segments at *Gamascolex* (*A*) and *Plasmuscolex* (*B*) *a* – non-contracted segments, *b* – segments at beginning of contraction, *c* – maximum contraction. Arrows indicate muscle contraction. Note origin of folds (*A-b*) and depressions (*B-b*) at the beginning of contraction

The contraction of palaeoscolecidan segments is significant, reaching almost 1/3 –1/4 of the non-contracted length (pl. IX, figs. 1, 2). Due to this strong contraction we suppose that intersegmental septa allowed migration of coelomic fluids, or that the external segmentation does not reflect underlying metameric one.

The function of tubercles as a penetration anchor (Conway-Morris - Robison 1986) is questionable. During body contraction the tubercles are not in contact with the sediment (except for the ventral side of *Gamascolex*) because of their location along segmental margins. The transversal sharp ridges originating during contraction in the central bands have more probably function as the penetration anchor.

The elastic lengthening and shortening developed in recent annelids have been partly substituted in palaeoscolecidans by folding and straightening of each segment. Locomotive propagate waves originating by the repeated folding – straightening cycles allowed crowling and burrowing of the palaeoscolecidans.

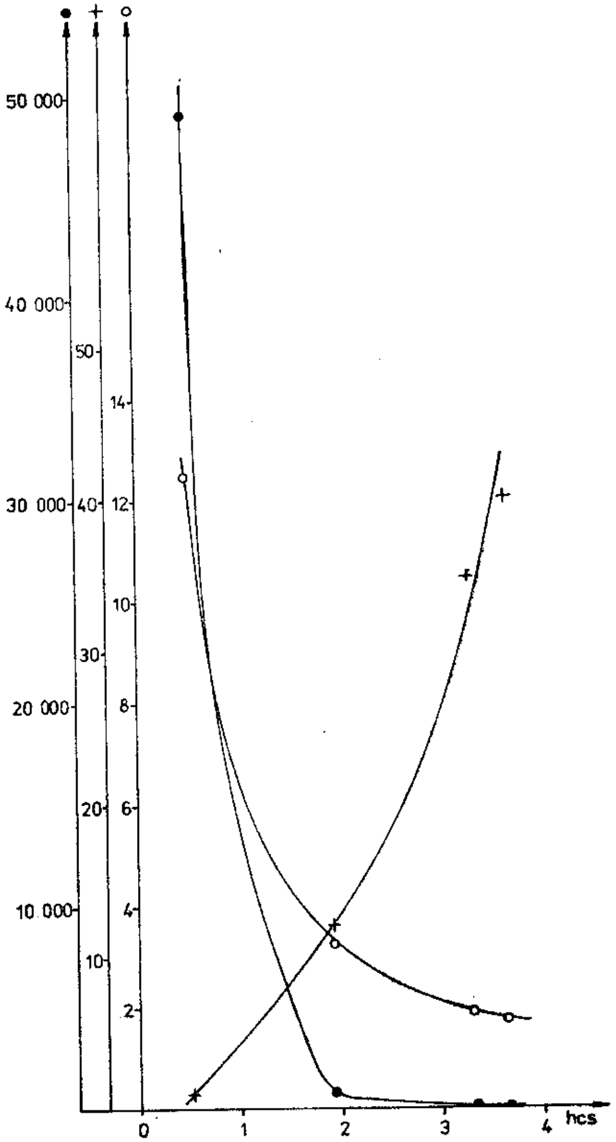
## Mode of life

Palaeoscolecidans were supposed deposit feeders (Whittard 1953). Their cylindrical body, absence of body appendages, and poorly or no differentiated dorsal and ventral sides indicate infaunal mode of life (Robison 1969; Conway-

Morris - Robison 1986). Trace od burrowing activity is preserved in *Plasmuscolex klabavensis* (specimen OMR 10 500). The short, cylindrical (secondarily flattened) coiled burrow is preserved close to the body terminal. This trace (*Planolites*-like) indicates infaunal mode of life of palaeoscolecidans, too.

## Growth

Four specimens of different size enable estimation of the growth changes during ontogeny in *Plasmuscolex klabavensis* (text-fig. 5).



5. Graphs indicating growth changes of *Plasmuscolex klabavensis*
Graphs showing dependence of *hcs* (in mm) on the:
*a* — number of tubercles equal to 1 mm$^3$ of body mass (*dot*), *b* — bulk of 10 mm long sequence of cylindrical body (in mm$^3$; *cross*), *c* — surface of body equal to 1 mm$^3$ of the body mass (in mm$^2$; *circle*). It is evident that palaeoscolecidans show quick relative growth during early adult stage. During evenly increasing bulk of body number of body outgrowths (= tubercles) and corresponding surface of body quickly decrease. This decrease was very quick originally but became more slow later

**Pathology**

Pathologic malformations are rather common in *Gamascolex*. Imperfect or irregular course of a segment is the most common malformation; it is marked by bifurcation or fusing of intersegmental furrows. Segments are discontinuous (pl. III, fig. 5) or fused (pl. III, fig. 4). Fine details of cuticle (tubercles a.o.) are often fused or show irregular course. Different malformations are represented by much shorter segments laying between longer ones (pl. IV, fig. 1). This pathologic malformation differs in ornamentation and tubercle shape, too. These pathologic malformations did not originate due to injury, they are more probably results of growth deffects of the animal.

?*Annelida* LAMARCK, 1809

*Palaeoscolecida* CONWAY-MORRIS et ROBISON, 1986

*Palaeoscolecidae* WHITTARD, 1953

Genera assigned: *Palaeoscolex* WHITTARD, 1953; Middle Cambrian – Lower Ordovician.
*Gamascolex* gen. n.; Lower Ordovician.
?*Protoscolex* ULRICH, 1878; Upper Ordovician – Upper Silurian.

Species probably belongs to the family: *Palaeoscolex antiquus* GLAESSNER, 1979; Lower Cambrian.

*Palaeoscolex* WHITTARD, 1953

"*Palaeoscolex*" *tenensis* sp. n.
Pl. I

Holotype: Specimen GS-MM 199, figured on pl. I.
Type horizon and locality: Arenigian, Klabava Formation, 4 metres above base; Těně.

Description: The fragment of flattened trunk less than 0.7mm wide, with prominent transversal rows of tubercles. Boundaries between segments indistinct. Tubercles densely arranged in transversal tubercle bands, probably two in each segment. All tubercles equal in shape and size. They are about twice longer than wide (maximum length is nearly 90 $\mu$m), elliptical, with strongly scalloped to spined margins of outer tubercle surface. The outer surface of tubercle concave, tubercle slopes vertical to nearly undercut. Inner tubercle surface (= corresponds to tubercle impression) is concave, too, and bears shallow circular pits in two longitudinal rows. Pits in spacing and number correspond to spines of outer tubercle surface. If the width of preserved trunk is equal to the whole cuticle, there are 40–50 tubercles in one tubercle band; T2 = 50–70.

### *Gamascolex* gen. n.

Type species: *Gamascolex herodes* gen. et sp. n.

Diagnosis: Large palaeoscolecidan with probably cylindrical body composed of more than 250 equal segments. Body with differentiated dorsal and ventral sides of the cuticle. Each segment with two transversal rows of tubercles; elongate dorsal flanking intersegmental furrows and circular ventral in central band. Outer surface of tubercles with prominent, paired tubercle projections. Microornamentation of fine epicuticular projections, papillae-like to mound-like in shape. Inner cuticle surface nearly smooth, with obscure tubercle impressions. Intersegmental furrow simple, narrow, sharply cut but rather shallow. Longitudinal ridge developed both on dorsal and ventral sides.

Discussion: *Gamascolex* differs by its tubercle shape and differentiated dorsal and ventral sides from *Palaeoscolex*. Moreover, the new genus attains much larger size than other palaeoscolecidans.

Species: *Gamascolex herodes* gen. et sp. n.; Ordovician, Dobrotivian, Dobrotivá Formation; Bohemia.

### *Gamascolex herodes* gen. et sp. n.

Pls. II–VI; pl. VIII, fig. 3

1978 *Paleoscolex* sp.; Mergl, p. 28

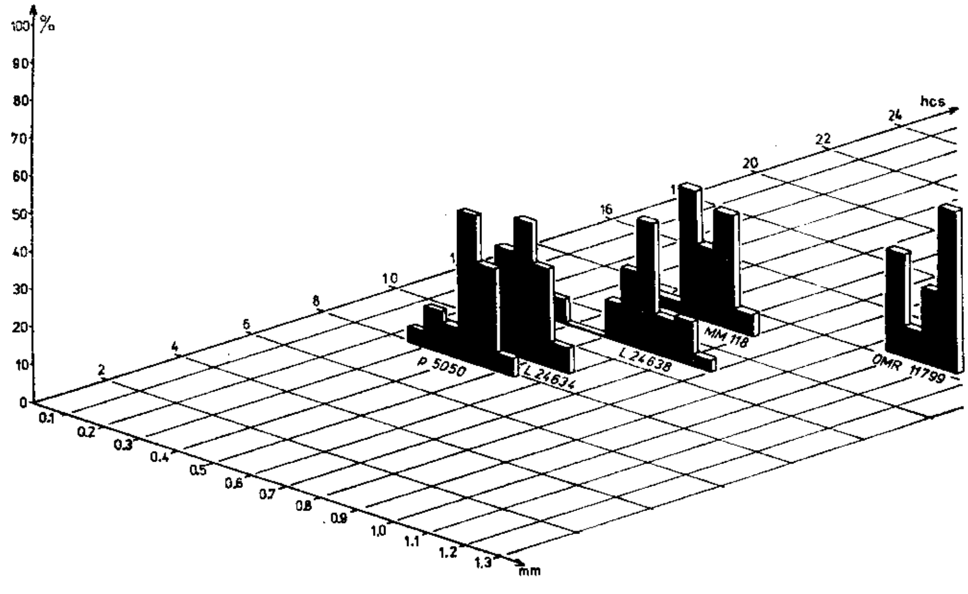
Holotype: Specimen NM-L 24634, figured on pl. III, figs. 1, 2 and pl. IV, figs. 1, 2, 4.
Type horizon and locality: Dobrotivian, Dobrotivá Formation; Malé Přílepy.

Shape of the body: The largest flattened specimen 20 mm wide (= 12 mm in diameter at originally cylindrical body), the smallest 7.5 mm wide (= 5 mm in diameter). Body slightly tapering at terminal parts, with terminals suddenly ended. Maximum of segments preserved is 248, the entire animal possesses 300 to 400 segments. Segments 0.4–1.2 mm long, their length depends on absolute size of the specimen, but within one specimen varies only a little (text-fig. 5). Intersegmental furrows narrow, sharply cut, shallow, simple. Judging from the fragments, the absolute length of non-contracted specimen may reach 20 to 40 cm. S10 = 9–25. T2 = 13–25.

Outer surface of the cuticle: The dorsal side of each segment (about 2/3 of body circumference) has two transverse bands of regularly spaced low tubercles along segment margins. The central band smooth apart from microornamentation. Dorsal tubercles 70–80 μm wide and 180–250 μm long, with slopes gently decreasing to the adjacent surface. Size and shape of tubercles correspond to location on the body (dorsally they are longer). Tubercle projections arranged in two longitudinal rows, arising from the outer surface of tubercles, numbered 12—14 on the dorsal side, laterally and ventrally their number decreases to 4 (2 pairs). Ventral third of the segment bears conus-shaped tubercles of circular outline, 90—110 μm in diameter and comparatively high, arranged in two irregular rows in the central band. Margins of segments on the ventral side are without tubercles or with minute, irregularly spaced tubercles of dorsal type. Ventral tubercles have 4 tubercle projections at their tops, identical in shape with those on the dorsal side. The contact of both tubercle types is rather sharp. The dorsal tubercles suddenly become much smaller, and are arranged closer to the intersegmental furrows. Ventral tubercles suddenly appear in the central band between dorsal ones. In one transverse row, there are 60 to 120 tubercles of dorsal type and 28 to 40 ones of ventral type. Their number is nearly identical at adjacent segments but decreases toward body terminals. On dorsal and ventral sides the fine longitudinal ridge, slightly elevated above segmental surface, is developed.

Microornamentation: The outer cuticular surface is densely covered, apart from tubercles, by very fine epicuticular projections, mound to papillae-like in shape. They cover the bottoms of intersegmental furrows, too. For details on their shape, size and spacing see chapter Morphology of cuticle.

Inner surface of the cuticle: The inner surface of the cuticle is smooth,



6. Histogram of segment length-variability of *Gamascolex herodes*
*hcs* — half circumference of segments (in mm), *mm* — length of segments (in mm), % — percentage presence; $n = 25-40$ segments

with prominent transversal ridges corresponding to the intersegmental furrows. Tubercle impressions poorly preserved, elongate in outline. Other internal structures not preserved.

### *Plasmuscolecidae* fam. n.

Diagnosis: Palaeoscolecidans with two transverse bands of indistinctly bordered tubercles on each segment, with tubercle tops and slopes covered by poorly differentiated tubercle projections. Dorsal and ventral sides not differentiated.

Discussion: *Plasmuscolecidae* differs from *Palaeoscolecidae* WHITTARD, 1953 in having a simpler external morphology of the cuticle, and especially poorly differentiated tubercles and tubercle projections.

Genus assigned: *Plasmuscolex* gen. n.; Lower Ordovician.

### *Plasmuscolex* gen. n.

Type species: *Plasmuscolex nero* gen. et sp. n.

Diagnosis: Medium-sized palaeoscolecidan with probably cylindrical body composed of more than 200 segments, with undifferentiated dorsal and ventral sides of the body. Segments equal in size, bordered by very deep intersegmental furrows. Each segment with nearly smooth central band, and two tubercle bands. Tubercles ridge-like, strong, elliptical to pear-shaped in outline, with indistinct boundaries, entirely covered by tubercle projections. Outer cuticular surface densely covered by epicuticular projections, more coarse at tubercle bands. Inner surface of cuticle with prominent ellipsoidal tubercle impressions. Number of tubercles at one tubercle band is nearly constant, and ranges from 50 to 70.

Discussion: *Plasmuscolex* differs from other palaeoscolecidans in having a different shape of tubercles and in poorly differentiated tubercle projections.

Species: *Plasmuscolex nero* gen. et sp. n.; Ordovician, Dobrotivian, Dobrotivá Formation; Bohemia.

*Plasmuscolex klabavensis* gen. et sp. n.; Ordovician, Arenigian, Klabava Formation; Bohemia.

### *Plasmuscolex nero* gen. et sp. n.

Pl. VII; pl. VIII, figs. 1, 2; pl. IX

1978 *Paleoscolex* sp. (sp. n.); MERGL, p. 44

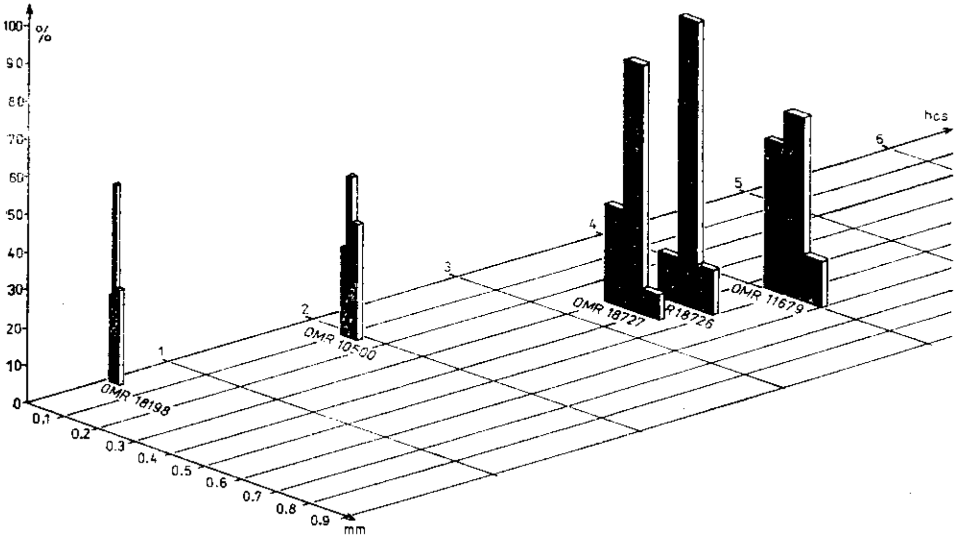
Holotype: Specimen OMR 11 679, figured on pl. VII, pl. VIII, figs. 1, 2 and pl. IX, figs. 4–6.

Type horizon and locality: Dobrotivian, Dobrotivá Formation; Sutice hill near Starý Plzenec.

**Shape of the body:** Flattened body 4.5 mm wide (= 4 mm in diameter in originally cylindrical body). Segments 0.45—0.55 mm long in non-contracted position, equal in size, separated by narrow, deep intersegmental furrows. The single known terminal of the body composed of identical segments, slightly tapering to the terminal. The maximum of segments preserved is 90, but entire animal possesses probably 200—300 segments. Absolute length of non-contracted specimen may reach 70—150 mm. S10 = 18—22.

**Outer surface of the cuticle:** Each segment possesses strongly elevated central band, 70—80 % as long as the segment, with both marginal tubercle bands steeply sloping toward intersegmental furrows. Both these slopes are deeply notched in regular intervals, forming zig-zag course of the central band. The strong, elliptical ridge, originating between two adjacent notches has an identical function as the tubercle in other palaeoscolecidans. Tubercle surfaces are covered with very fine tubercle projections, arranged in several (6—8) longitudinal rows. The tubercle projections are the largest at the tubercle tops and moderately decrease in size toward tubercle margins, near the bottom of notches they pass into epicuticular projections without clear boundaries. Dorsal and ventral longitudinal ridges very fine, preserved only at bottoms of notches. One tubercle row exhibits 55—60 tubercles.

**Microornamentation:** The bottoms of notches in tubercle bands are covered with regularly spaced (in oblique rows), papillae-like epicuticular projections. They are less than 5 μm in diameter being slightly higher than wide. The surface



7. Histogram of segment length-variability of *Plasmuscolex klabavensis* and *P. nero* species
Explanation as in text-fig. 6

of central bands is covered with low, pustule-like, densely crowded epicuticular projections, less than 3 μm in diameter.

Inner surface of the cuticle: Inner surface of the cuticle bears on each side of segment a lot of short, sharp ridges corresponding with the notches of the outer surface of the cuticle. Elliptical, deeply cut tubercle impressions are developed between ridges; their surface is convex internally.

Internal structures of the body: Specimen NM-L 24635 has preserved 0.6 mm wide and 2 mm long cylindrical structure, which may be sedimentary infilling of the intestine.

### *Plasmuscolex klabavensis* gen. et sp. n.

Pls. X–XIII

Holotype: Specimen OMR 18726 figured on pl. X as fig. 1, 2 and pl. XI.

Type horizon and locality: Arenigian, Klabava Formation, Tetragraptus abbreviatus Biozone; Klabava, Starý hrad.

Shape of the body: The largest flattened specimen is 3.5 mm wide (= 2.3 mm in diameter), the smallest only 0.5 mm wide (= 0.3 mm in diameter). Overall shape of the body is the same as that in *P. nero*. Maximum of segments preserved is 250. Segments are 0.04–0.4 mm long, their length depends on specimen size. Absolute size of non-contracted specimens ranges from 10 mm to more than 100–150 mm. S10 = nearly 275 in minute specimen; in adults 20–30.

Outer surface of the cuticle: In arrangement of tubercles, tubercle projections and shape, size, and spacing of epicuticular projections this species is the same as *P. nero*, differs only in having pear-shaped outline of tubercles.

## Family uncertain

### *Bohemoscolex* gen. n.

Type species: *Bohemoscolex holubi* gen. et sp. n.

Diagnosis: Large palaeoscolecidan-like worm with body composed of more than 150 (probably several hundreds) identical segments. Dorsal and ventral sides probably undifferentiated; intersegmental furrows sharp and deep. Central band with gently wrinkled, shallow groove. Surface of segments smooth, with no signs of tubercles or papillae except for very minute (less than 30 μm in diameter) circular structure irregularly spaced. Narrow, sharply cut longitudinal furrow is developed on the ventral (?) side.

Discussion: *Bohemoscolex* is assigned to the palaeoscolecidans on the basis of 1) very long body composed of several hundreds identical segments with distinct boundaries, 2) rather rigid cuticle, and 3) by thinner cuticle along central bands allowing folding of contracted segments. However, the new genus lacks tubercles and the outer surface of the cuticle does not bear epicuticular projections. Moreover, palaeoscolecidans have developed longitudinal ridge; this is substituted by a deep furrow in *Bohemoscolex*. Polygonal structure of cuticle is unknown in other palaeoscolecidans, too.

Species assigned: *Bohemoscolex holubi* gen. et sp. n.; Ordovician Arenigian, Klabava Formation; Bohemia.

### *Bohemoscolex holubi* gen. et sp. n.

Pl. XIV

Holotype: Specimen OMR 9595 figured on pl. XIV.

Type horizon and locality: Arenigian, Klabava Formation, Corymbograptus v-similis Biozone; Rokycany — hospital.

Name: After Karel Holub, outstanding collector in Rokycany.

Shape of body: Flattened body 11 mm wide (= 7 mm in diameter at originally cylindrical body). Body terminals unknown. Maximum of segments preserved is nearly 90. Segments 0.6—0.7 mm long, all subequal in length. Intersegmental furrows narrow, deep, simple. Judging from a single coiled specimen, the absolute length may reach minimally 8—12 cm in uncontracted specimen. S10 = 16—18.

Outer surface of the cuticle: Tubercle bands smooth, without tubercles or similar structures. Central band with wrinkled shallow groove. Remaining surface of the cuticle with minute circular structures, irregularly spaced, at some places forming indistinct, longitudinal rows. These structures represent shallow pits or hollow secondarily broken outgrowths infilled with clayey substance. Narrow sharp and deep longitudinal furrow is developed on the ventral (?) side. SEM investigation shows small areas with polygonal structures, irregularly spaced on the outer surface of cuticle. Polygons are about 8 μm in diameter, bordered by less than 1 μm wide interspaces. This structure of cuticle may be interpreted as imprints of epithelian supporting cells (compare epithelian moulds of some fossil inarticulate brachiopods; CURRY - WILLIAMS 1983). The structure and arrangement of fine circular structures irregularly spaced on the surface of the cuticle recall papillae in intrapapillate zone of *Palaeoscolex antiquus* GLAESSNER, 1979.

### *Palaeoscolecida* gen. indet. A

Pl. XV

Description: Body finely segmented. Cuticle composed of several layers, with some structures dissimilar and/or showing reverse spatial orientation of the structures in comparison with other palaeoscolecidans. Single fragment (pl. XV) is probably a positive imprint, showing outer surface of the cuticle. Specimen shares with palaeoscolecidans deep intersegmental furrows, rigid cuticle, and slightly contracted segments forming folds. Tubercle projections form outgrowths more or less regularly spaced in shallow depressions.

However, tubercles are substituted by shallow depressions of semiglobular shape; they are arranged along intersegmental furrows and their number is unclear. Epicuticular projections are substituted by shallow pits, covering whole surface of the segment. Close to segmental margins they are longitudinally elongate, become nearly circular to hexagonal in outline at central bands. The bottoms of the pits are smooth, but their walls are vertically striated.

If available imprint represents an external mould, then segments are bordered by strong ridges, structures of cuticle are reverse compared to aforementioned ones, and contractions of segments originate by concave bending.

Occurrence: Arenigian, Klabava Formation, Tetragraptus abbreviatus Biozone; Klabava — Starý hrad locality.

### *Palaeoscolecida* gen. indet. B

Description: Distinctly segmented, 14.3 mm long fragment of a trunk, due to poor preservation with only segmentation preserved. Maximum width = 6.7 mm, length of segment 0.25—0.3 mm. S10 = 38—42.

Occurrence: Arenigian, Klabava Formation, Holograptus tardibrachiatus Biozone; Rokycany — Valcha locality.

### *Palaeoscolecida* gen. indet. C

Description: Short part of distinctly segmented trunk with no other structures visible. Length of trunk = 25 mm, maximum of width = 8 mm, length of segment 0.3—0.4 mm. S10 = 26—27.

Occurrence: Llanvirnian, Šárka Formation, Corymbograptus retroflexus Biozone; Mýto locality.

### ?*Chaetognatha* LEUCKART, 1854

### Class, Order and Family uncertain

### *Titerina* gen. n.

Type species: *Titerina rokycanensis* gen. et sp. n.

Description: Worm-like body minute, elongate, at mid-length gently widened. Anterior part distinctly differentiated. Jaw apparatus composed of a single pair of large, hollow, slightly incurved spines, with anterior ends narrowly pointed (= grasping spines). The anterior part of the body exhibited preserved intestine. Both sides of intestine are bordered by narrow, axially strongly elongate structures, which have the same location as ovaria at recent chaetognaths. In posterior terminal of a single specimen the remains of fibrillar structure are preserved (= fin ?). The posterior third of the body (behind the intestine) contains globular, tiny (less than 70 μm in diameter) bodies, with shallow concave depression on their surfaces (pl. XVI, fig. 5).

Preservation: All specimens are preserved in dark brown organic substance, forming thin film on the bedding plane. Grasping spines, some parts of intestine and globular bodies show three-dimensional preservation. Ovaria and remaining parts of the intestine are flattened and are distinguishable by their darker colour only. Minute globular bodies are fossilized by transparent, brown-red substance.

Remarks: *Titerina* recalls *Chaetognatha* by its anatomy, but this assignment is only provisional. *Spadella* (according HYMAN 1959) is morphologically the closest to the new genus. *Titerina* shares with *Chaetognatha*: 1) elongate, worm-like body of minute size; 2) jaw apparatus with paired, slightly incurved grasping spines. *Titerina* has one pair, but recent chaetognaths have four pairs minimally. Complex, multipaired grasping spine apparatus is known from the Cambrian (SZAMAWSKI 1982), but grasping spines may be absent in poorly developed specimens (SCHRAM 1973); 3) The intestine of *Titerina* ends at 3/5 of the body length and determines location of the trunk-tail septum and anus. The space in the posterior part of the body may correspond to tail coelom of recent chaetognaths; 4) remains of fibres at the posterior terminal of the body recall by location and shape supporting rays in the fin of recent chaetognaths; 5) elongate, narrow spots running parallel with the body axis and rimming the intestine recall by location and shape the ovaria of recent chaetognaths.

Species assigned: Type species only.

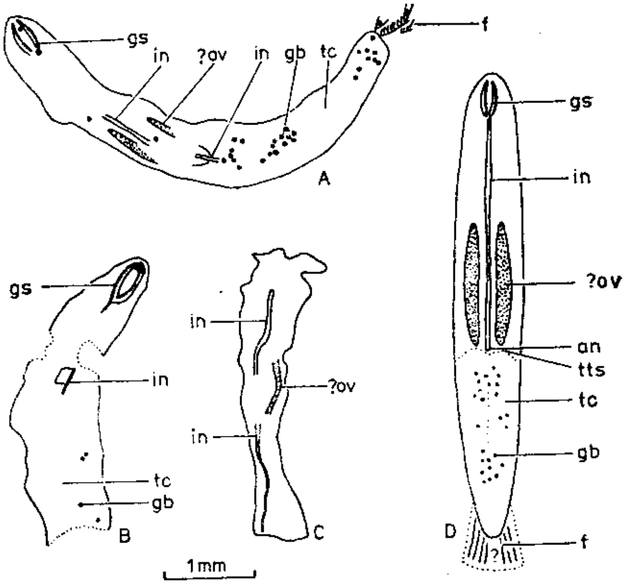
### *Titerina rokycanensis* gen. et sp. n.

Pl. XVI, text-fig. 8

Holotype: Specimen OMR 15334A figured on pl. XVI as figs. 1, 4; text-fig. 8A.

Type horizon and locality: Arenigian, Klabava Formation, Holograptus tardibrachiatus Biozone; Rokycany — Stráň (gully, section 7).

Description: see description of the genus. The width of the intestine depends on mode of preservation, non-deformed has 40 μm in diameter, width of the flattened one ranges from 10 to 250 μm. Posterior end of the intestine reaches 3/5 of the body length. The paired elongate structures bounding the intestine (ovaria) have anterior ends at half-length the intestine, and nearly reach trunk-tail septum. The globular tiny bodies with concave depression at their surfaces have been observed mainly at posterior part of the body. They have been found at specimens OMR 15334A (35 bodies) and OMR 15334B (3 bodies). The diameter of these



8. *Titerina rokycanensis* gen. et sp. n.
Specimens OMR 15334A (*A*), 15334B (*B*), 15334C (*C*), and reconstruction of anatomy (*D*)
*an* — anus, *gb* — globular bodies, *gs* — grasping spines, *f* — fin, *in* — intestine, *?ov* — ovaria, *tc* — tail coelom, *tts* — trunk-tail septum

Table 3

Dimensions of *Titerina rokycanensis* gen. et sp. n.

| specimen | length of body (in mm) | maximum of body width (in mm) | length of grasping-spines (in mm) | width of grasping spines (in mm) |
|---|---|---|---|---|
| OMR 15334A | 4.9 | 0.7 | 0.41 | 0.06 |
| OMR 15334B | 3.1 | 0.9 | 0.48 | 0.06 |
| OMR 15334C | 3.4 | 0.6? | — | — |

bodies ranges from 20 to 70 μm, and apart from 4 bodies, all have been found at posterior third of the body. Close to specimen 15334B and 15334C a lot of minute, cylindrical, 50—70 μm long and 35—55 μm wide dark bodies have been found. They are distributed near the posterior third of specimens and may be interpreted as coprolites. Specimen 15334C shows squeezing of these bodies from broken part of the intestine.

*K tisku doporučil M. Plička*

*Přeložil M. Mergl*

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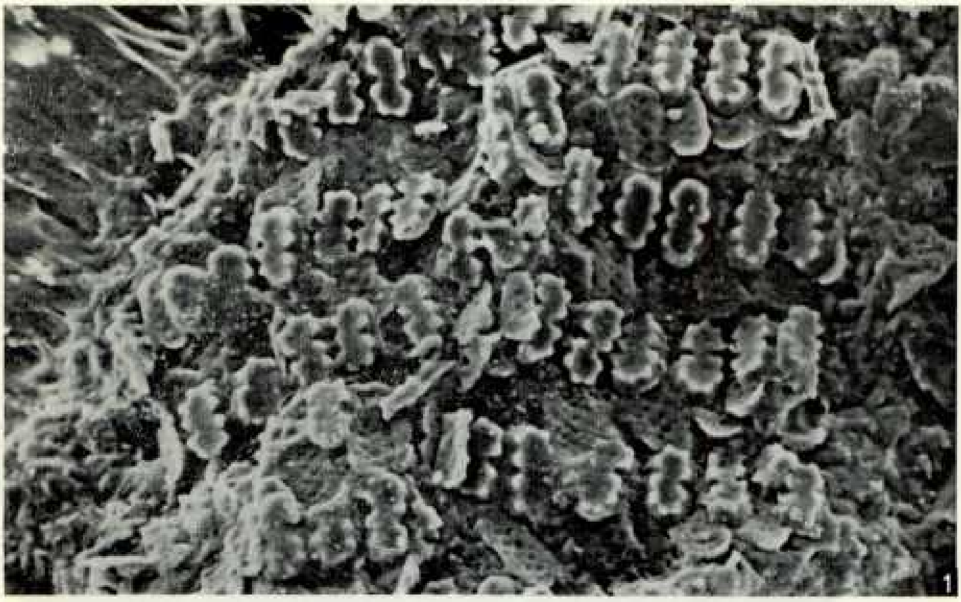
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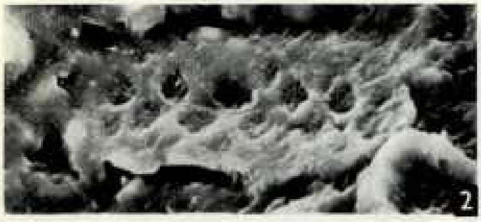
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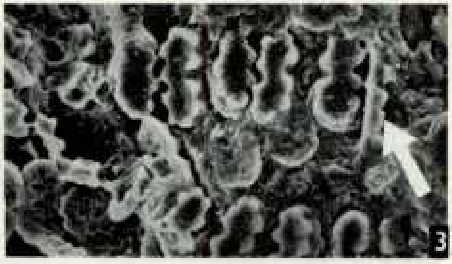
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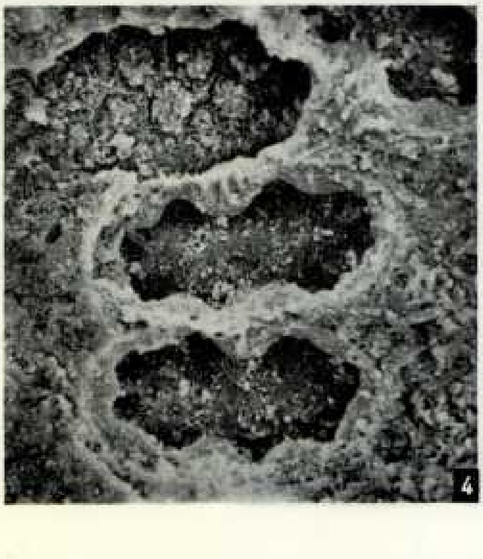
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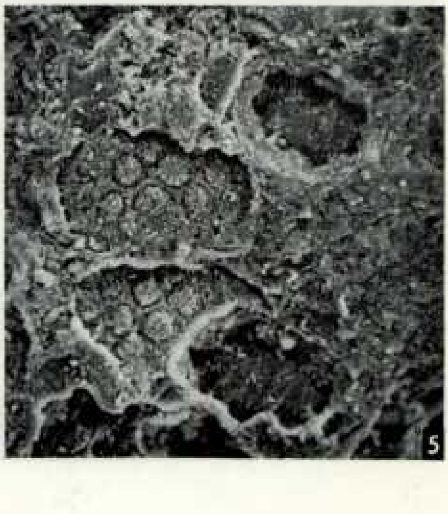
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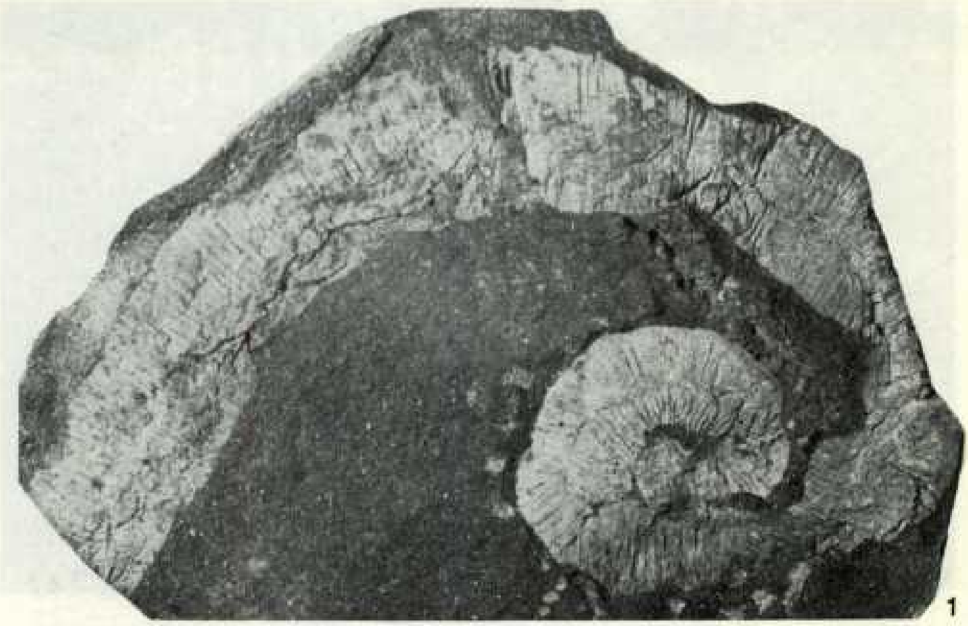

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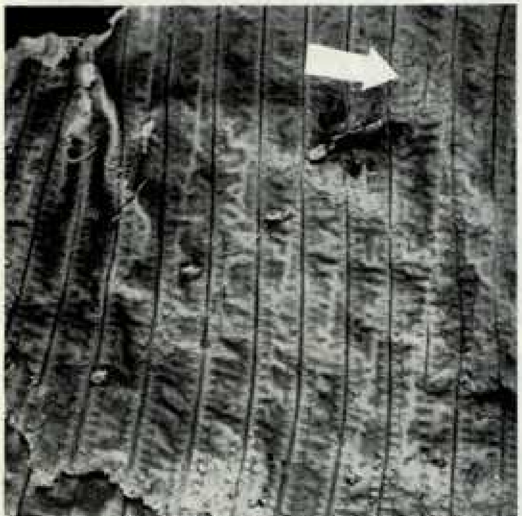
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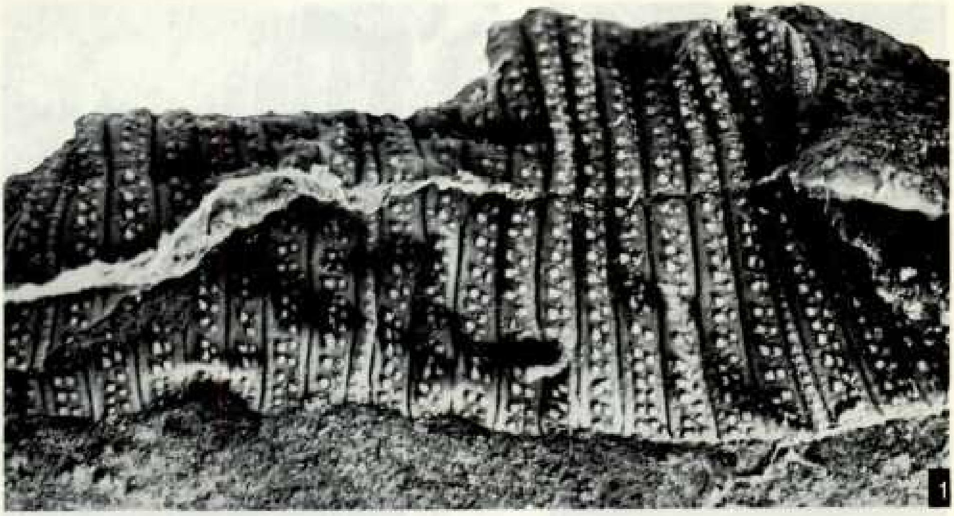

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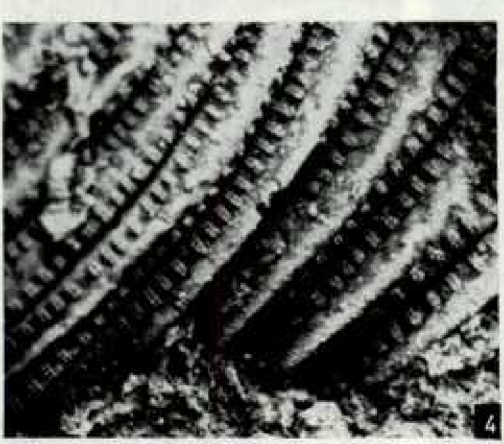

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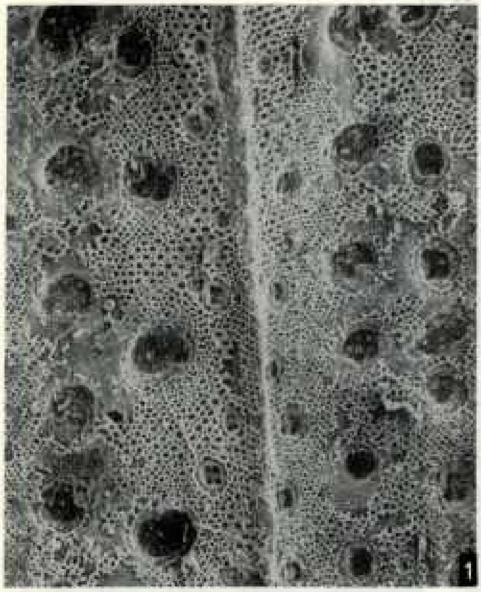
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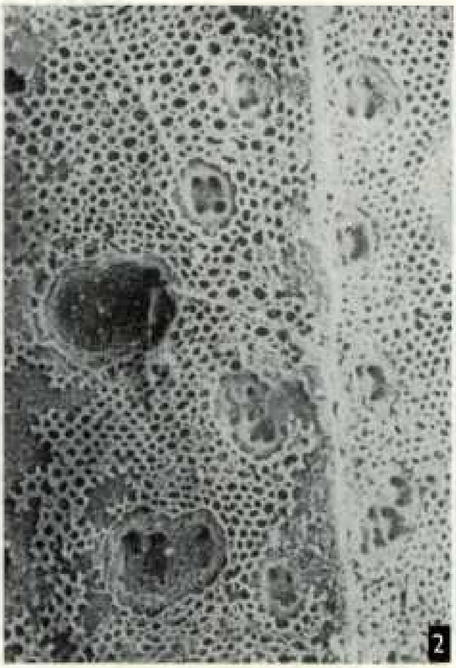
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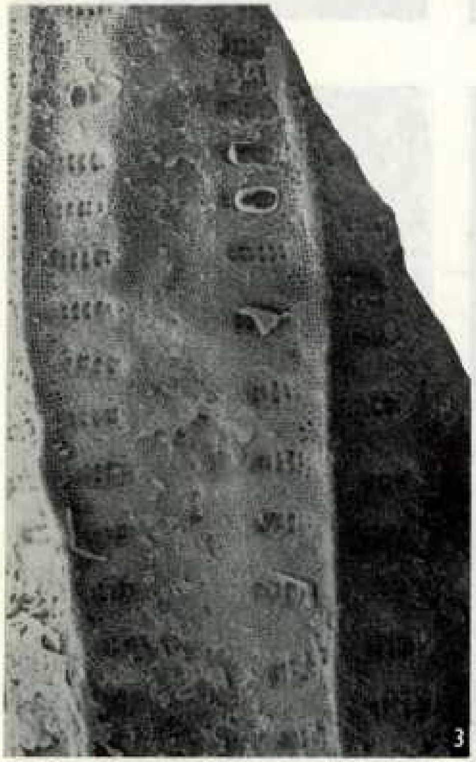
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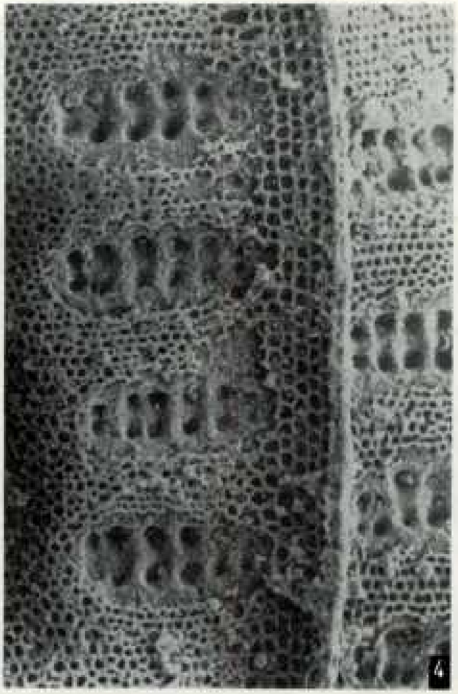
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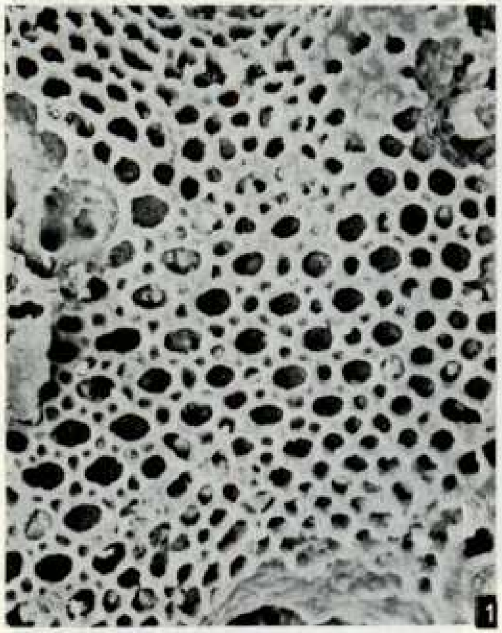
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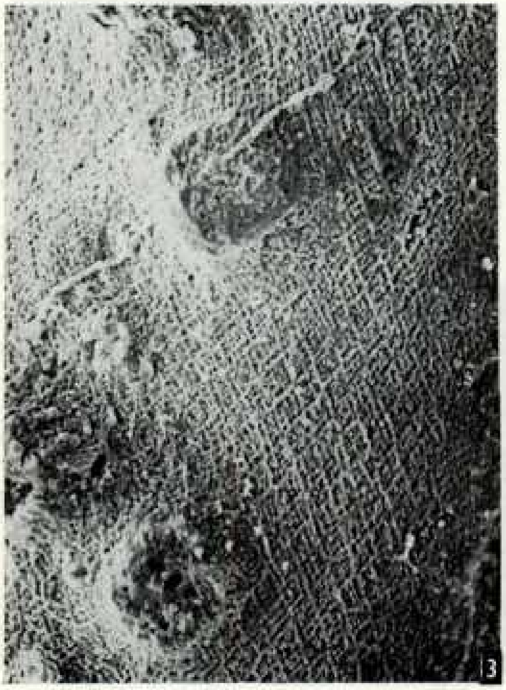
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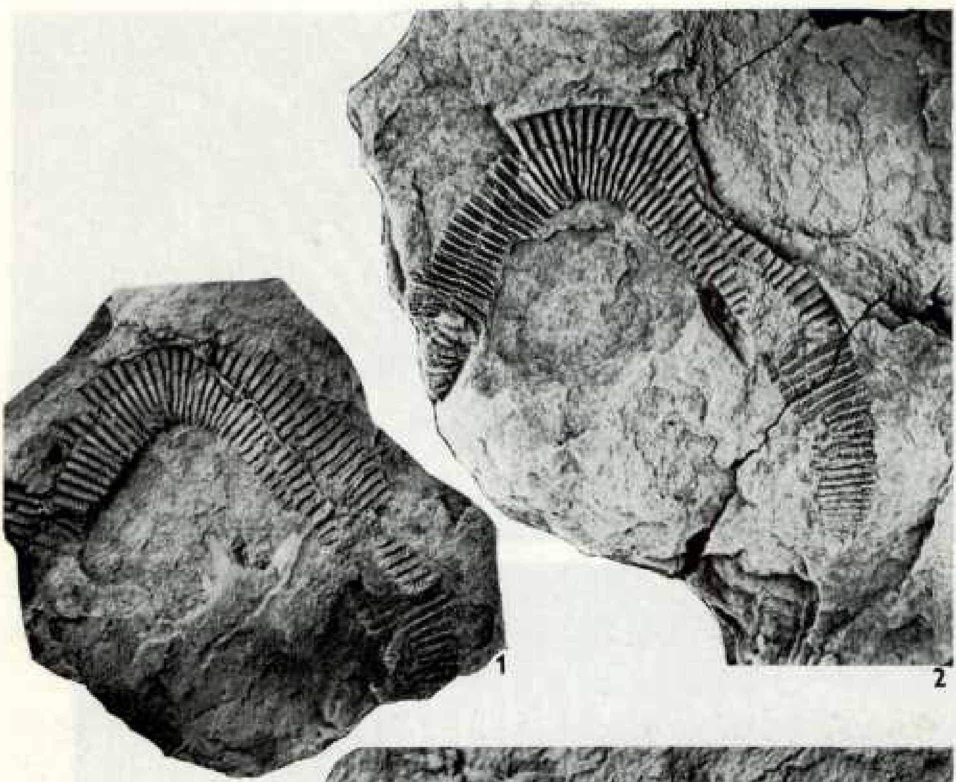
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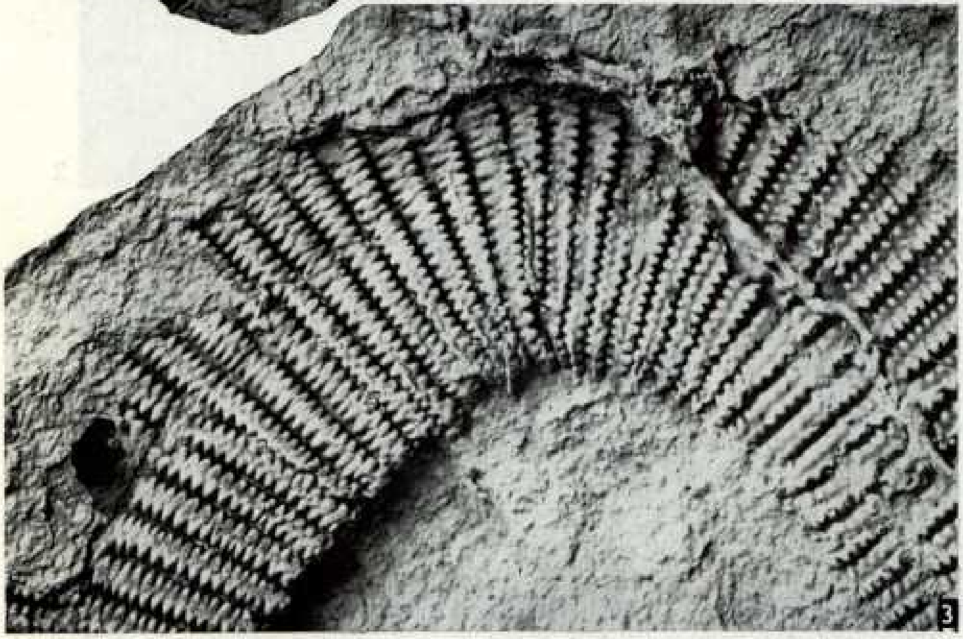
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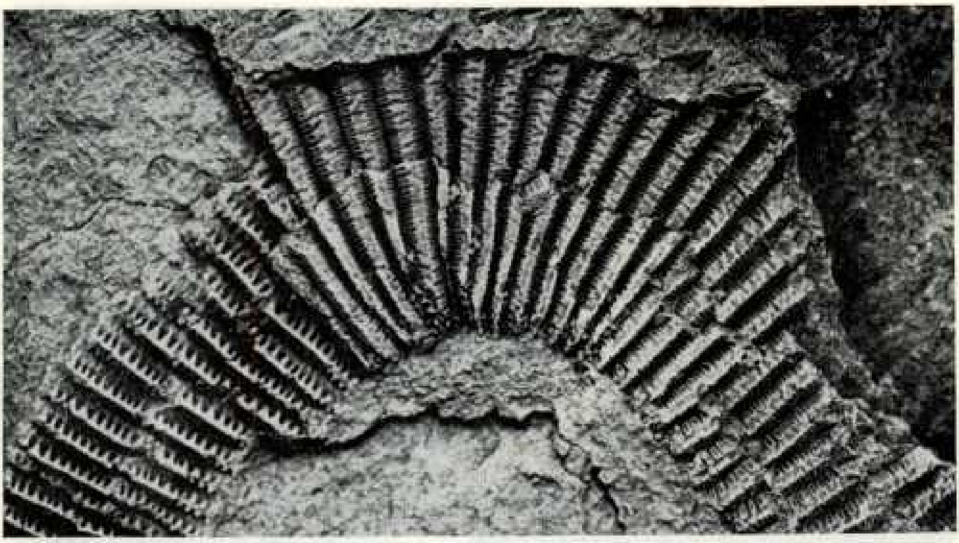

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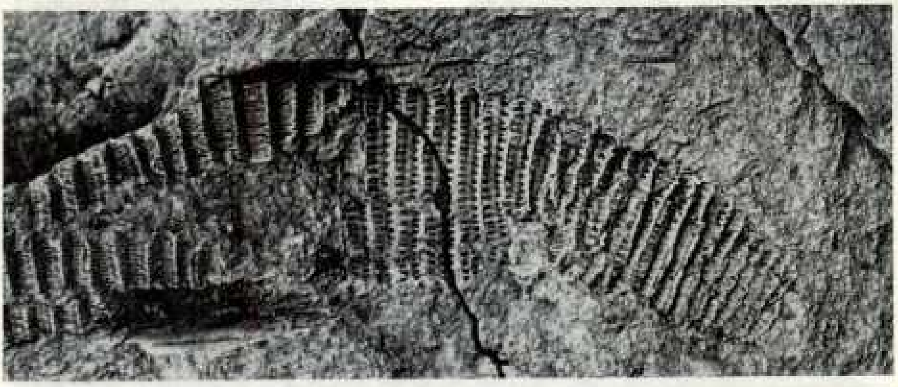

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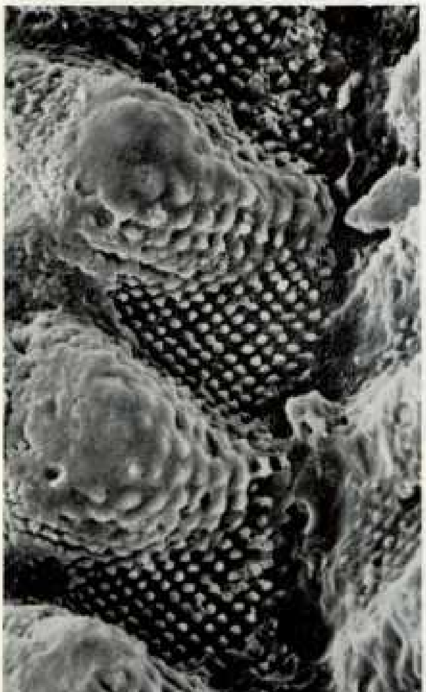
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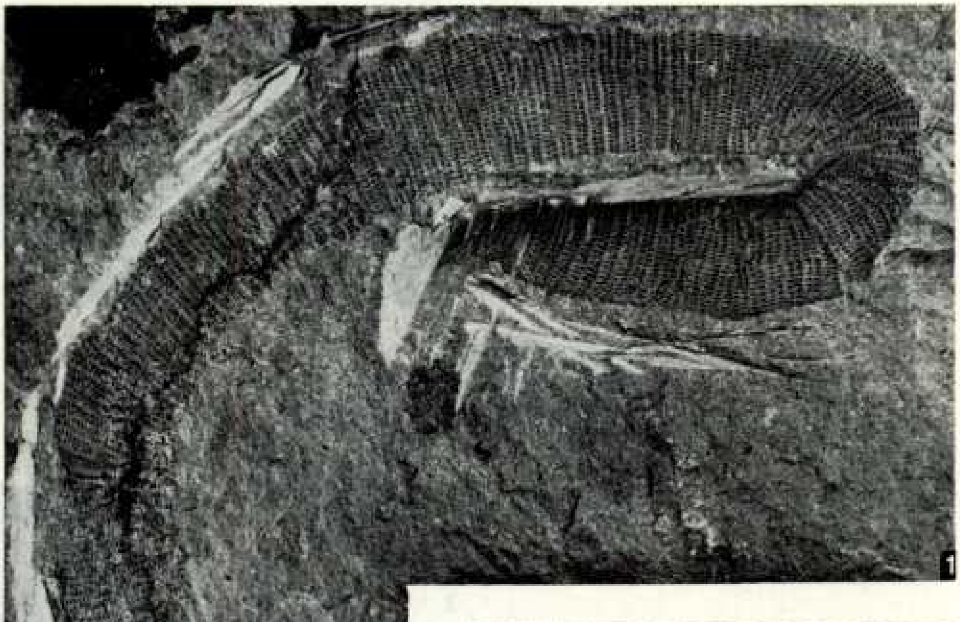
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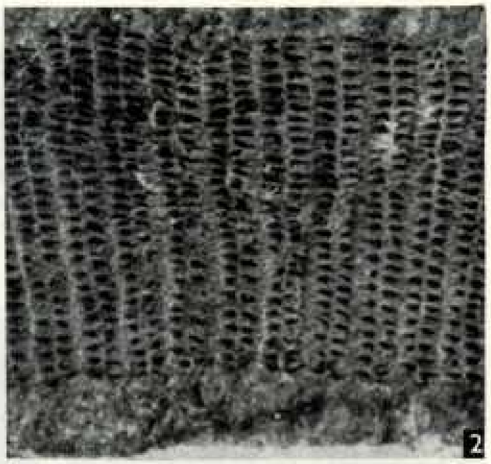
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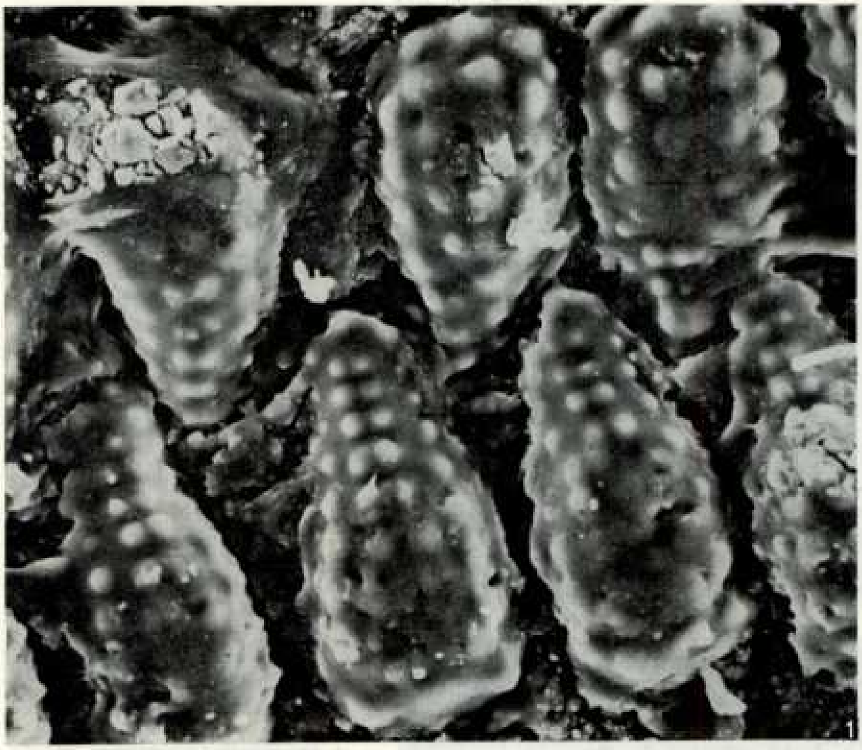
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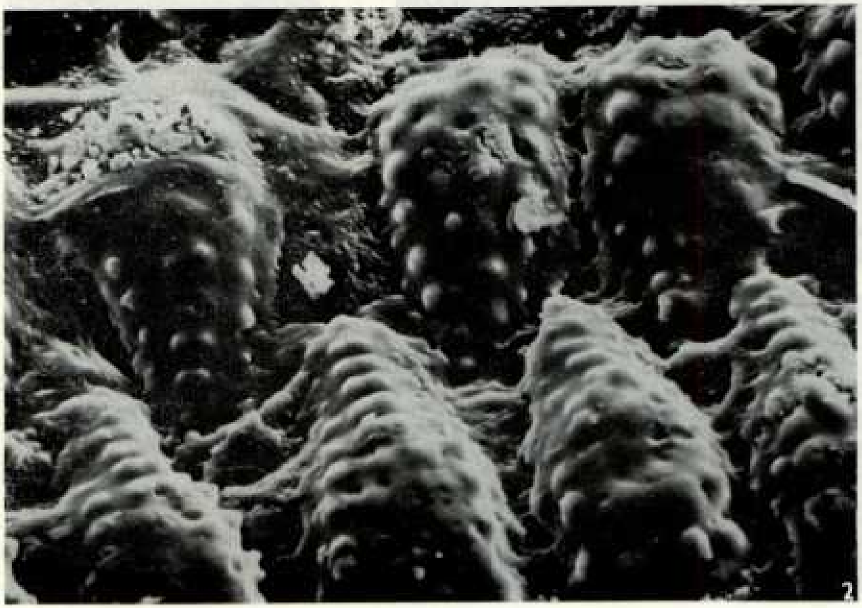
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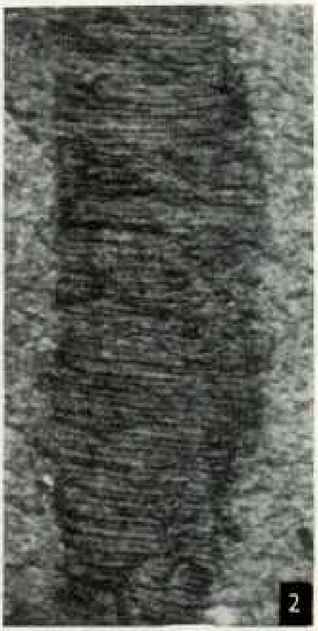
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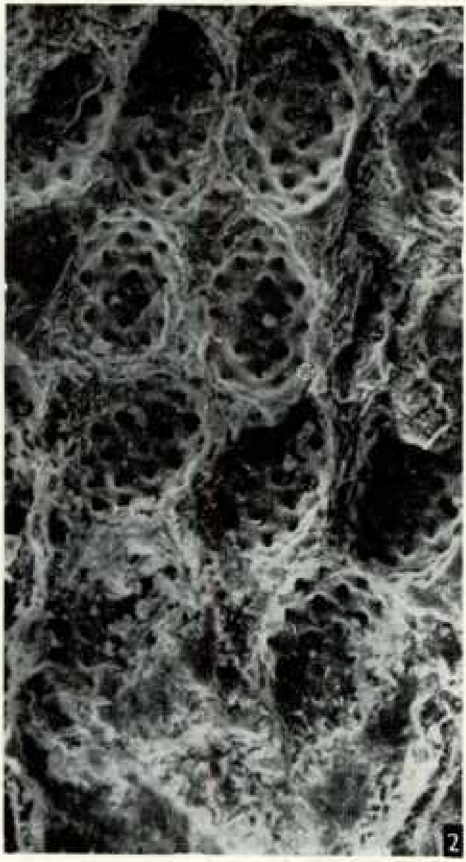
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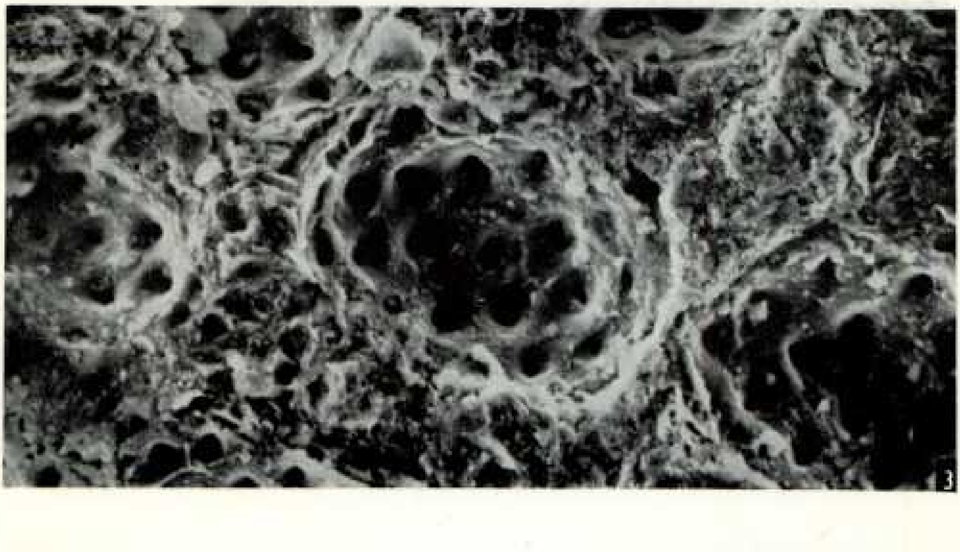
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Pl. XIV


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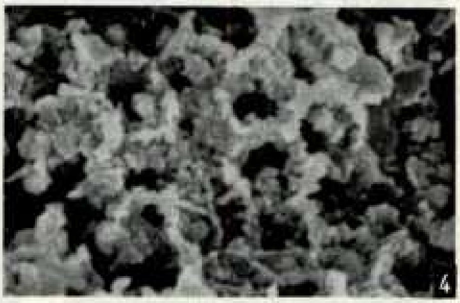
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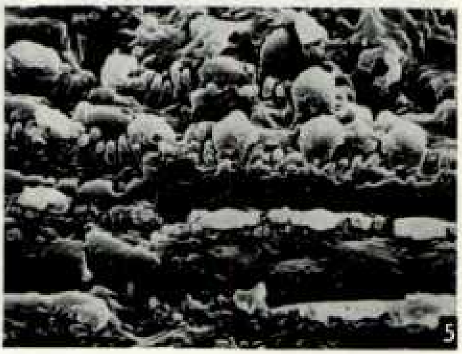
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Pl. XVI


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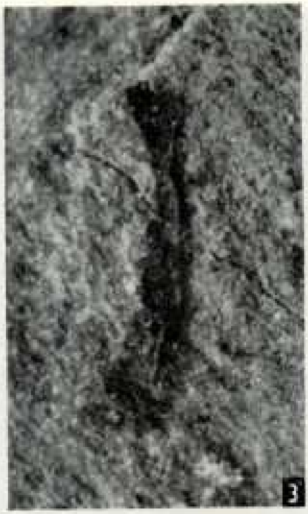
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## Explanation of plates

### Pl. I

"*Palaeoscolex*" *tenensis* gen. et sp. n.

Specimen GS-MM 199, Klabava Formation, Těně locality; latex casts (1–3), external moulds (4,5); SEM photo (1–5).

1,3 – transversal rows of tubercles, showing spined outer and pitted inner surfaces of tubercles, arrow indicates vertically oriented tubercle, ×150, ×150; 2 – inner surface of tubercle, ×490; 4,5 – inner and outer surfaces of tubercles, ×370, ×250.

### Pl. II

*Gamascolex herodes* gen. et sp. n.

Specimen GS-p 5050, Dobrotivá Formation, Malé Přílepy locality; uncoated external mould (1), latex casts coated with ammonium chloride (2,3).

1 – almost complete specimen, composed of more than 250 segments, ×2.8; 2 – coiled trunk showing folded segments at ventral side, ×9.0; 3 – trunk showing ventral (left) and dorsal (right) tubercles, ×9.0.

### Pl. III

*Gamascolex herodes* gen. et sp. n.

Specimens NM-L 24634 (1, 2) and GS-MM 118 (3–5), Dobrotivá Formation, Malé Přílepy locality; latex casts coated with ammonium chloride (1–5).

1, 2 – outer and inner surfaces of cuticle, the same part of trunk, ×20, ×20; 3 – outer dorsal surface of cuticle, ×10; 4, 5 – pathologic segments, arrow indicates discontinuous intersegmental furrow, ×10, ×25.

### Pl. IV

*Gamascolex herodes* gen. et sp. n.

Specimens NM-L 24634 (1, 2, 4), GS-NM 118 (3, 5), Dobrotivá Formation, Malé Přílepy locality; latex casts coated with ammonium chloride (1, 2, 4) and SEM photos (3, 5).

1 – outer surface of cuticle, ventral side near body axis, ×18; 2 – longitudinal ridge on ventral side, ×25; 3 – outer surface of cuticle with original substance preserved, note mound-like epicuticular projections surrounded by ventral type tubercles, ×140; 4 – outer surface of cuticle, dorsal side, showing tubercles, and folds at central bands originating during contraction, ×25. 5 – bottom of intersegmental furrow with epicuticular projections, ×140.

### Pl. V

*Gamascolex herodes* gen. et sp. n.

Specimen GS-MM 118, Dobrotivá Formation, Malé Přílepy locality; external moulds (1–4), SEM photos (1–4).

1, 2 – external moulds of outer surface of cuticle, ventral sides showing large circular pits (= tubercles) and minute pitting (= epicuticular projections), ×70, ×140; 3, 4 – external moulds of outer surface of cuticle, dorsal sides showing elliptical areas with two rows of pits (= tubercles with tubercle projections) and fine pitting (= epicuticular projections) ×45, ×140.

Pl. VI

*Gamascolex herodes* gen. et sp. n.
Specimen GS-MM 118, Dobrotivá Formation, Malé Přílepy locality; external moulds (1, 2) and original cuticle substance (3, 4); SEM photos (1–4).
1 – external mould of outer surface of cuticle, ventral side showing alternating of two size categories of epicuticular projections, ×350; 2 – external mould of dorsal type tubercle on ventral side, ×700; 3, 4 – cross-lamellar structure of original cuticular substance, ×180, ×700.

Pl. VII

*Plasmuscolex nero* gen. et sp. n.
Specimen OMR 11679, Dobrotivá Formation, Sutice hill near Starý Plzenec locality; internal mould (2), and latex casts (1,3); coated with ammonium chloride (1–3).
1–3 – trunk with terminal, holotype, ×3, ×3, ×10.

Pl. VIII

*Plasmuscolex nero* gen. et sp. n.
Specimen OMR 11679, Dobrotivá Formation, Sutice hill near Starý Plzenec locality; internal (1) and external (2) moulds; coated with ammonium chloride (1, 2).
1, 2 – part of trunk showing negative imprint of inner surface of cuticle and tapering body terminal, ×10, ×10.
*Gamascolex herodes* gen. et sp. n.
Specimen OMR 11799, Dobrotivá Formation, Hůrka hill near Starý Plzenec locality; imprint in shale; coated with ammonium chloride.
3 – dorsal side of large specimen, ×10.

Pl. IX

*Plasmuscolex nero* gen. et sp. n.
Specimens NM-L 24635 (1–3) and OMR 11679 (4–6), Dobrotivá Formation, Šárka (1–3) and Sutice hill near Starý Plzenec (4–6) localities; latex casts (1–6); coated with ammonium chloride (1–3), SEM photos (4–6).
1–3 – trunk with contracted terminal parts, ×10, ×10, ×4; 4, 5 – five incomplete segments showing outer surface of cuticle with tubercles, tubercle projections and epicuticular projections, ×35, ×150; 6 – the same part, oblique view, ×80.

Pl. X

*Plasmuscolex klabavensis* gen. et sp. n.
Specimens OMR 18726 (1,2), and OMR 18198 (3), Klabava Formation, Klabava – Starý hrad locality; uncoated imprints (1–3).
1, 2 – almost complete specimens flattened in shale and detail of segments, ×5, ×15; 3 – minute complete specimen with partly preserved substance of cuticle, ×12.

Pl. XI

*Plasmuscolex klabavensis* gen. et sp. n.
Specimen OMR 18726, Klabava Formation, Klabava – Starý hrad locality; latex casts; SEM photos.
1, 2 – detail of several tubercles in vertical and oblique views, ×280, ×280.

Pl. XII

*Plasmuscolex klabavensis* gen. et sp. n.
Specimens OMR 18198 (4,5) and OMR 10500 (1–3), Klabava Formation, Rokycany – Stráň

(quarry) (1–3), and Klabava – Starý hrad (4, 5) localities; imprints (1–3) and latex casts (4, 5); uncoated specimens (1, 2), and SEM photos (3–5).
1, 2 – almost complete specimen flattened in shale and detail of segmentation, ×5, ×15; 3 – negative imprint of epicuticular projection (on the left), ×350; 4, 5 – part of trunk with partly contracted segments, and detail of segments, ×100, ×450.

### Pl. XIII

*Plasmuscolex klabavensis* gen. et sp. n.
Specimen OMR 18727, Klabava Formation, Klabava – Starý hrad locality; imprint (1), external moulds (2, 3); uncoated specimen (1), SEM photos (2, 3).
1 – fragmental flattened trunk in shale, ×5; 2, 3 – detail of tubercles with tubercle projections ×200, ×500.

### Pl. XIV

*Bohemoscolex holubi* gen. et sp. n.
Specimen OMR 9595, Klabava Formation, Rokycany – hospital locality; imprint with cuticle substance preserved; uncoated (1), coated with ammonium chloride (2, 3), and SEM photo (4).
1 – incomplete flattened specimen in shale, ×2.5; 2, 3 – details of trunk with segments, central bands and longitudinal furrow preserved, ×5, ×7; 4 – polygonal structure of cuticle, ×800.

### Pl. XV

*Palaeoscolecida* gen. indet. A
Specimen OMR 18171, Klabava Formation, Klabava – Starý hrad locality; imprints (1–4) and latex cast (5); SEM photos (1–5).
1 – several segments showing segment boundaries and pitting of cuticle, ×350; 2 – the same part, showing tubercle pits and details of cuticular surface, ×1600; 3 – several segments, ×265; 4 – epicuticular pits at central band with scalloped outline, ×3600; 5 – part of segment with large tubercles (?) and epicuticular projections (?), ×370.

### Pl. XVI

*Titerina rokycanensis* gen. et sp. n.
Specimens OMR 15334A (1, 4), OMR 15334B (2,5), and OMR 15334C (3), Klabava Formation, Rokycany – Stráň (gully, section 7) locality; imprints (1–5); uncoated specimens (1–4) SEM photo (5).
1, 4 – complete specimen with grasping spines and ovaria, and enlarged anterior end of body, ×15, ×60; 2 – incomplete specimen with anterior end and grasping spines preserved, ×15; 3 – incomplete specimen with intestine preserved, ×15; 5 – globular body with concave depression on the right, ×950.

Photographs on pl. XVI, fig. 4 made by M. Kunst, all SEM made by J. Kulich, remaining by authors.

# Vermiformní fosilie (Palaeoscolecida; ?Chaetognatha) ze spodního ordoviku Čech

(*Résumé anglického textu*)

Petr Kraft – Michal Mergl

Předloženo 6. října 1986

Paleoskolecidi (?*Annelida*) představují charakteristickou skupinu vermiformních metazoí. V zahraničí se vyskytují v marinních sedimentech kambrického až silurského stáří; z Čech jsou známi pouze ze spodního ordoviku (arening—dobrotiv). Jejich kutikula, dokonale zachovalá díky fosfatizaci, má poměrně složitou morfologii. Její povrch je typicky členěn (tuberkule, epikutikulární výrůstky aj.); kutikula je laminována a připomíná podobné struktury v kutikule recentních annelidů. Svou vnější morfologií paleoskolecidi připomínají kromě annelidů i nematody a priapulidy, avšak vzhledem k nedostatku údajů o vnitřní anatomii a morfologii tělních zakončení je jejich pozice v systému nevyjasněná. V systematické části je popsána 1 nová čeleď, 3 nové rody a 5 nových druhů.

Kromě toho je popsán drobný organismus, který svou velikostí, vnější morfologií, přítomností čelistního aparátu a vnitřní anatomií připomíná ploutvenky (*Chaetognatha*). Tento organismus je přiřazen k novému rodu *Titerina*.

## **Ископаемые червеобразные** (*Palaeoscolecida*; ? *Chaetognatha*) **из нижнего ордовика Чехии**

*Palaeoscolecida* (? *Annelida*) известны с кембрия по силур; в Чехии они встречаются лишь с аренига по добротив. Степень сохраненности индивидов из Чехии позволяет детально описать морфологию кутикулы, ультраструктур и обсудить систематическую позицию палеосколецидов. Обсуждаются также их способ движения и образ жизни. Определяются семейство *Plasmuscolecidae* и роды *Bohemoscolex*, *Gamascolex* и *Plasmuscolex*. В систематической части описано пять новых видов и три неопределимых индивида. В качестве дополнения описан новый род *Titerina* (*T. rokycanensis* sp. n.), относящийся, вероятно, к *Chaetognatha*.

*Přeložil A. Kříž*

| Sbor.<br>geol. věd | Paleontologie<br>30 | Pages<br>37—59 | 2<br>figs. | 1<br>tab. | 4<br>pls. | Praha 1989<br>ISSN 0036-5297 |
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# The hyoliths of the Králův Dvůr Formation (Bohemian Ordovician)

## Hyoliti králodvorského souvrství českého ordoviku

Ladislav Marek[1]

Received October 6, 1986

Marek L. (1989): The hyoliths of the Králův Dvůr Formation (Bohemian Ordovician). — Sbor. geol. Věd, Paleont., 30, 37—59. Praha.

Abstract: All known species of hyoliths from the Králův Dvůr Formation of the Bohemian Ordovician are described or their descriptions completed. The species are attributed to appropriate genera. In the Králův Dvůr Formation the following genera were ascertained: *Circotheca, Nephrotheca, Panitheca, Bactrotheca, Elegantilites, Joachimilites, Gompholites, Leolites, Decipilites, Recilites?* and probably *Sololites*. Seven new species and 2 new genera, *Mediolites* gen. n. and *Raitilites* gen. n. were established. At present, 15 species of hyoliths are known from the Kralodvor, 4 of them in the open nomenclature.

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### Introduction

During a systematic field paleontological research in the Bohemian Ordovician a rich material of hyoliths was collected in the Králův Dvůr Formation, enabling to widen substantially our knowledge of the character of hyolith assemblages of this stratigraphical unit. It appeared that a number of significant genera known from earlier formations (Llanvirn, Dobrotiv and mainly Beroun) passed into the Kralodvor where their occurrence ends. From the overlying Kosov Formation, the youngest unit of the Bohemian Ordovician, only two indeterminable fragments of hyolithids were ascertained.

### History of the research

The history of the research of hyoliths from the Králův Dvůr Formation is very brief and the bibliography is restricted to only three items, above all to the monographs of J. Barrande and O. Novák. Barrande (1867) described from the Kralodvor (the lower part of his band Dd5) two species: *Hyolithes decipiens* Barr. and

*H. indistinctus* BARR. According to BARRANDE, the occurrence of the first species mentioned is limited only to Dd5, whereas *H. indistinctus* is reported incorrectly by this author also from the Vinice and Zahořany Formations (Barrande's bands Dd3 and Dd4). BARRANDE also mentioned the occurrence of two other species in the Králův Dvůr Formation, namely *H. striatulus* BARR. and *H. undulatus* BARR. The occurrence of these species in the band Dd5 was already refuted by NOVÁK (1891).

NOVÁK (1891) added to the list of the Kralodvorian hyoliths two new valid species, *Bactrotheca deleta* NOV. and *Hyolithus sulcatulus* NOV.

MAREK (1977) established a new genus *Decipilites* based on *Hyolithes decipiens* BARR. and ranged it to the family *Pauxillitidae.*

Such was the state of knowledge of hyoliths of the Králův Dvůr Formation, when the work on this paper began. Only four species were known from which no one (with the exception of *Bactrotheca deleta*) could be used to clear up the relations of generic hyolith assemblages of the Kralodvor to those of earlier Bohemian Ordovician Formations.

## Localities and mode of preservation

There are not many localities available in the Králův Dvůr Formation and localities yielding hyoliths are scarce. It appeared that the layer richest in hyoliths lies close to the base of overlying Kosov Formation. This fossiliferous layer formed by dark grey-green clayey shales and calcareous shales crops out on several places of the Prague Basin, but the greatest part of the material derives from Mt. Kosov near Králův Dvůr. Other finds of hyoliths in the Králův Dvůr Formation were made only occasionally, partly in temporary outcrops. The list of localities yielding the material for this paper is given below.

Kosov — abandoned quarry at the NW slope of Mt. Kosov above the cement factory at Beroun-Králův Dvůr. In the SW part of this quarry the above mentioned layer with hyoliths and other fauna was exposed in the uppermost parts of the Králův Dvůr Formation about 1.6 m below the base of the Kosov Formation (MAREK 1952, 1964). This layer was known already to Barrande from some other place at the foot of Mt. Kosov. Below the shales with abundant hyoliths about 40 cm thick, lies a calcareous layer maximum 30 cm thick, containing also common hyoliths (*Bactrotheca, Panitheca, Sololites?*) besides a rich assemblage of trilobites and brachiopods: *Duftonia morrisiana, Cryptolithus kosoviensis, Stenopareia oblita, Zdicella sola, Diacalymene asperula, Staurocephalus clavifrons, Aegironetes tristis, Kozlowskites rangari,* etc.

The above mentioned layers were also exposed in the railroad cutting at Zadní Třebaň, in a steep hillside near the village Karlík and at Liteň. CHLUPÁČ (1951, 1952) reports some hyolith species from these localities, now practically inaccessible.

Králův Dvůr – Barrande's classic locality at the sheep farm ("U ovčína") close to the fork of roads to Suchomasty and to Karlova Huť. This locality has been inaccessible for about three decades and new material could not be therefore collected. The material housed in the collections of the National Museum and partly in the Paleontological Department of the Faculty of Natural Sciences, Charles University, Prague is mostly very poorly preserved in greenish claystones.

Lejškov – another classic, long forgotten locality of Barrande, rediscovered more than 30 years ago by the present author. This locality lies in the ravin between the western part of the hill Lejškov and Libomyšl. Fossiliferous dark gray claystones crop out in the bed of a creek NE of the former farmhouse called Vyšebohy and are hardly accessible as they lay under the water level. The claystones contained small calcareous nodules with perfectly preserved trilobites and rare hyoliths [*Elegantilites* cf. *indistinctus* (Barr.)]. A small number of compressed and deformed hyoliths was found also in the claystones.

Praha-Spořilov. Lower layers of Králův Dvůr Formation were temporarily uncovered during building of new houses SE of the the tram terminal between the present (1987) streets Na Chodovci and Hrusická. Greenish claystones yielded here a fairly rich fauna with prevailing trilobites: *Amphitryon radians* (Barr.), *Raphiophorus tenellus* (Barr.), *Carmon mutillus* Barr., *Areia bohemica* Barr. etc. Common hyoliths are represented by new taxa, but the specimens are strongly compressed.

Praha-Nusle (Jezerka). A thin calcareous layer stratigraphically corresponding to the layer from Kosov is exposed in the park above the Nuselská Street. The faunistic assemblage is composed of brachiopods, trilobites etc., hyoliths are rare and poorly preserved.

Praha-Michle (Rajtknechtka). Temporary outcrops SW of Tyršův vrch hill made in early eighties. Exposed here was an oolitic layer yielding a rich and well preserved fauna showing certain affinities to the fauna of the upper Bohdalec Formation. However, this layer called the "Podolí ore horizon" is conventionally ranged to the base of the Králův Dvůr Formation. *Bactrotheca rediviva* is the most common hyolith in this locality, undeterminable species of *Elegantilites* occurs scarcely.

A great deficiency of the material studied is its strong pressure deformation in claystones and clayey shales. This mode of preservation prevents to ascertain the outline of the cross-section of conchs and their contingent curvature. The only exception is the scarce material from Lejškov, collected in the last century and represented by calcareous internal molds. Uncompressed is also the material from the oolitic rock on the base of the Králův Dvůr Formation.

Most specimens are preserved as composite molds enabling in many cases to distinguish the dorsal and ventral sculptures on the conchs and to ascertain the number and position of clavicles on the opercula. Also the position of the bases of cardinal processes can be observed but the detailed morphology of all these structures remains unknown.

## Relations of the Kralodvor hyoliths to the older Ordovician hyoliths in Bohemia

Despite very unfavourable preservation of the material studied it was possible to ascertain in the Králův Dvůr Formation the occurrence of ten hyolith genera of the orders Orthothecida and Hyolithida, known from older formations: *Circotheca, Bactrotheca, Nephrotheca, Panitheca, Elegantilites, Joachimilites, Gompho-*

Table 1

Distribution of hyolith genera in the Bohemian Ordovician

| Formations / Genera | Klabava | Šárka | Dobrotivá | Libeň | Letná | Vinice | Zahořany | Bohdalec | Králův Dvůr |
|---|---|---|---|---|---|---|---|---|---|
| *Circotheca* | | | ○ | | | | | | ○ |
| *Nephrotheca* | ○? | ○ | ○ | | | | ○ | ○ | ○ |
| *Panitheca* | | | ○ | | | | ○ | ○ | ○ |
| *Bactrotheca* | | ○ | ○ | ○ | | | ○ | ○ | ○ |
| *Brevitheca* | | | | | | | ○ | | |
| *Elegantilites* | ○ | ● | ○ | ○ | | ○ | ○ | ○ | ○ |
| *Joachimilites* | | | | | | | ○ | ○ | ○ |
| *Eumorpholites* | | | | ○ | | | ○ | ○ | |
| *Gamalites* | | | ○ | | | | | | |
| *Dilytes* | | ○ | | | | | | | |
| *Gompholites* | | ○ | ○ | | | ○ | ○ | ○ | ○ |
| *Sololites* | | | | | | ○ | | | ○? |
| *Cavernolites* | | ○ | ○ | | | | | | |
| *Pauxillites* | | ○ | ○ | | | | | | |
| *Recilites* | | | | | ○ | ○ | ○ | ○ | ○? |
| *Leolites* | | | | | ○ | ○ | ○ | | ○ |
| *Decipilites* | | | | | | | | | ○ |
| *Mediolites* | | | | | | | | | ○ |
| *"Carinolithes"* | | | | ○ | | | | | |
| *Neurolites* | | | ○ | | | | | | |
| *Chimerolites* | | | | | | | ○ | | |
| *Raitilites* | | | | | | | | | ○ |
| Number of genera | 2 | 7 | 10 | 4 | 2 | 5 | 11 | 8 | 13 |

•○●X

*lites, Leolites, Recilites?* and probably also *Sololites*. The other characteristic Ordovician hyolith genera known from Llanvirn, Dobrotiv and Beroun have not been found in Kralodvor as they most probably became extinct. They are for instance *Cavernolites, Pauxillites, Eumorpholites, Gamalites* and "*Carinolithes*". On the other hand, the genus *Decipilites* is known only from the Králův Dvůr Formation (see tab. 1 showing the stratigraphical range of the Bohemian Ordovician hyolith genera).

## Systematic part

### Class *Hyolitha*

### Order *Orthothecida* MAREK, 1966

### *Circothecidae* MISSARZHEVSKI, 1969

### *Circotheca* SYSSOIEV, 1958

Type species: *Hyolithes (Orthotheca) stylus* HOLM, 1893. Middle Cambrian, Sweden.

### *Circotheca neptis* sp. n.

Pl. I, figs. 1, 2

Holotype: Incomplete conch, figured here on pl. I, figs. 1, 2. LM 186.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Praha-Kačerov?.
Material: Only holotype, incomplete steinkern and counterpart underformed in nodule.

Description: Conch of circular cross-section. The fragment does not allow to recognize, whether the conch was straight or curved. The aperture is perpendicular to the longitudinal axis of conch. Its margin is almost straight, only very slightly anteriorly arched on the ventral side and posteriorly arched on the dorsal side. The thickness of the shell-wall decreases rapidly close to the edge of the aperture. This is perceptible on the steinkern at a comparatively sharply bordered vaulting around the aperture. The angle of divergence measured on the steinkern makes 6—7 degrees.

The surface of the conch bears very obscure fine growth-lines, visible only on few places.

The operculum is unknown.

Dimensions: The length of the conch is estimated for only a little over 20 mm. The diameter of the aperture measured on the steinkern is 2.8 mm.

Remarks: The conch of the type species of *Circotheca*, *C. styla* (HOLM) from the Swedish Middle Cambrian bears longitudinal elements of the sculpture mentioned by HOLM (1983, p. 53) and well preserved in some specimens from Holm's collection housed in the Swedish Geological Survey in Uppsala (Paleont. Coll. SGU, No. 292). *Circotheca hofensis* (BARRANDE, 1868), *C. caperai* MAREK, 1983 b (both Tremadocian species) and few other yet undescribed Lower and Middle Cambrian and Ordovician species of this genus bear a characteristic sculpture of narrow undulating or zig-zag longitudinal lamellae. *Circotheca neptis* sp. n. is lacking in longitudinal sculpture. In this feature, *C. neptis* differs from other known Ordovician species and represents the youngest species of circothecid hyoliths yet known.

Occurrence: This species was found in one nodule coming doubtless from the Králův Dvůr Formation as proved by associated trilobite species *Lonchodomas portlocki* (BARR.) and *Carmon mutillus* (BARR.). The last mentioned species indicates the lower parts of the above formation. The nodule derives from the dump at Praha-Zbraslav. The rock material came most probably from the excavations of the Prague Metro at Praha-Kačerov.

## *Orthothecidae* SYSSOIEV, 1958

### *Nephrotheca* MAREK, 1966

Type species: *Orthotheca sarkaensis* NOVÁK, 1891. Ordovician (Šárka Formation), Bohemia.

### *Nephrotheca ruderalis* sp. n.

Pl. I, figs. 3, 4; text-fig. 1

Holotype: Steinkern, figured here on pl. 1, fig. 3. LM 187.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Praha-Kačerov?.
Material: In addition to the holotype, two more specimens undeformed by pressure.

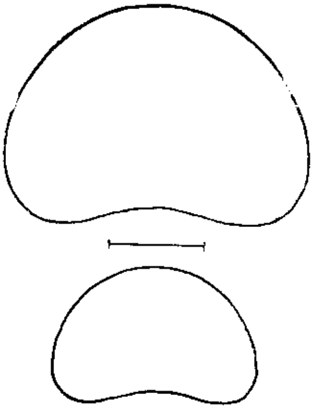
Description: The conch is dorso-ventrally curved, its posterior part bent slightly upwards. The cross-section is kidney-shaped. The angle of divergence makes about 12 degrees. W/h ratio = 1.4. The dorsal side is strongly inflated, the ventral side is concave. The lateral edges are strongly rounded and lie at about one-third height of the conch. The ventral apertural margin is straight, with its central part almost imperceptibly adapically arcuated. The dorsal apertural margin is broadly arched adapically. The aperture is oblique in lateral view, with its lateral margin inclined upwards and backwards in a very moderate arc. The depth of the ventral concavity equals approx. one-thirteenth height of conch and its width attains about three-fifths of conch's breadth. The internal surface of conch is smooth, without any trace of muscle scars.

Ventral side bears very low, comparatively broad rounded riblets. They number

6 – 7 per mm close to the aperture. Same riblets are developed on the dorsal side, where they are less marked.

The operculum is unknown.

Dimensions: Adult conch attained an estimated length minimum of 14 to 15 mm. Apertural width of the holotype amounts to 3.0 mm, height equals 2.15 mm.



1. *Nephrotheca ruderalis* sp. n., cross-sections of steinkern, LM 187 (pl. I, fig. 3). Bar = 1 mm

Remarks: Although the operculum of this species is unknown, the morphology of the conch witnesses its appurtenance to the genus *Nephrotheca*. It is the shape of the cross-section, which is kidney-shaped and very similar to that of the type species of *Nephrotheca*, *N. sarkaensis* (Novák) and the presence of rounded longitudinal riblets. *N. ruderalis* sp. n. differs from the above mentioned species in more concave ventral side (one-thirteenth height of conch against one-fifteenth in *N. sarkaensis*) and in smaller number of riblets on ventral side (6 – 7 per mm in the new species, about 9 in *N. sarkaensis*).

Occurrence: This species was found in the same nodule as *Circotheca neptis* sp. n. and derives also most probably from the diggings in Praha-Kačerov.

### *Nephrotheca*? sp. n.

Pl. I, fig. 15

Material: 1 compressed conch in claystone.

Description: Only the ventral side of this species is known, showing, despite of its unfavourable preservation, that the conch was concave in its axial part. The ventral apertural margin is straight but other details of the shape of aperture are unknown. The angle of divergence was not worth measuring due to substantial distortion.

The surface of the ventral side is smooth except for very fine transverse growth-lines close to the aperture.

Dimensions: The length of conch measures 16 mm, the width of aperture makes 4.9 mm.

Remarks: This specimen most probably represents a new orthothecid species that can be ranged tentatively and with certain doubts to the genus *Nephrotheca*, although it is lacking in longitudinal sculpture. Such a morphological type was as yet unknown among the Bohemian Ordovician representatives of the family *Orthothecidae*. Two orthothecid species without longitudinal sculpture of the conch have been described by MAREK (1983) from the Ordovician of Morocco. They are *Nephrotheca? destombesi* and *Nephrotheca?* sp., both hardly comparable with the Bohemian species, due to different preservation. A similar morphological type can be found in the Middle Cambrian species "*Orthotheca*" *affinis* HOLM, 1893.

Occurrence: Lejškov (Barrande's collection).

### *Panitheca* MAREK, 1967

Type species: *Panitheca collector* MAREK, 1967. Ordovician (Zahořany Formation), Bohemia.

### *Panitheca* aff. *collector* MAREK, 1967

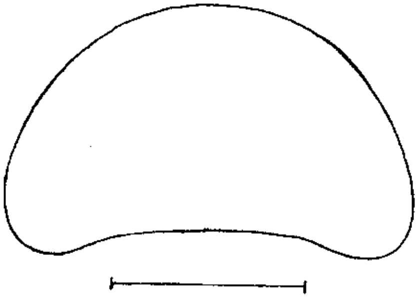
Pl. I, figs. 5–7; text-fig. 2

Material: One almost complete conch and two fragmentary conchs.

Description: Conch narrow, elongate, the angle of divergence measured on compressed specimen makes about 12 degrees. The cross-section is kidney-shaped with broadly concave ventral side and almost semicircular dorsal side. Strongly rounded lateral edges lie at about one-fifth height of the conch, w/h index = 1.65. The shape of the aperture can be reconstructed from the course of very fine growth-lines which are almost straight both on the ventral and dorsal sides.

The sculpture consists of very thin longitudinal zig-zag lamellae of unequal width, counting about 15 per mm. The growth-lines are faint.

The operculum is unknown.



2. *Panitheca* aff. *collector* MAREK, cross-section of conch, LM 190 (pl. I, fig. 7). Bar = 1 mm

**Dimensions:** The almost complete specimen (LM 189) measures 21.0 mm in length.

**Remarks:** This species is very similar to *Panitheca collector* from the upper Zahořany and Bohdalec Formations. The only perceptible slight difference between these two species is in the outline of the cross-section. The lateral edges in *P. collector* lie at about one-seventh to one-eight height of the conch, while in this species at about one-fifth height. This ratio was obtained from the measurement of only one specimen and is therefore not very reliable. A new, better preserved material is necessary for final decision on this question. *P.* aff. *collector* is the youngest representative of the genus *Panitheca* in the Ordovician as yet known.

**Occurrence:** This species was found only at Kosov.

### *Bactrotheca* NOVÁK, 1891

**Type species:** *Hyolithes teres* BARRANDE, 1867, Ordovician (Llanvirn), Bohemia.

### *Bactrotheca deleta* NOVÁK, 1891

Pl. I, figs. 8–10

1891 *Bactrotheca deleta* Nov.; NOVÁK, p. 35, pl. 6, figs. 17–21.
1893 *H.* (*O.*) *deletus* (Nov.); HOLM, p. 24 .
1946 *H.* (*O.*) *deletus* (NOVÁK), 1891; SINCLAIR, p. 75.
1962 *O.*? *deleta* Nov.; SYSSOIEV, p. 10.

**Lectotype:** Specimen figured by NOVÁK (1891) on pl. 6, fig. 17. NM L 26105.
**Stratum typicum:** Králův Dvůr Formation.
**Locus typicus:** Králův Dvůr.
**Material:** 12 conchs and 2 opercula.

**Description:** The conch is elongated, narrow, the angle of divergence of flattened conch makes about 11–12 degrees. The cross-section of conch is unknown but from the outline of operculum it is possible to deduce that it was roundedly quadrangular. The aperture is straight but its exact shape is unknown.

The sculpture consists of sharp, comparatively sparsely spaced longitudinal lamellae (5–7 per mm at the aperture), crossed by more densely spaced and a little less distinct transverse lamellae. The crossing of the lamellae gives the sculpture a lattice-like appearance. The spaces between the longitudinal and transverse lamellae have the form of rectangules with concave planes (convex on external molds).

The operculum is subrectangular with slightly arched lateral sides, distinct broadly diverging plicae and one pair of cardinal processes of unknown shape.

**Dimensions:** The length of conch exceeded 20 mm; the conch of the lectotype is 19.5 mm long, its width at the aperture attains cca 4.5 mm.

**Remarks:** This species is similar to *B. teres* NOVÁK from the Šárka Formation

(Llanvirn) which differs in bigger size of conchs and in the sculpture that is less distinctly lattice-like. The operculum of this species has more rounded edges. Another Bohemian species, *B. rediviva* (Marek) from the Berounian differs in closely spaced undulated lamellae which are the dominant sculpture of the conch in this species. *B. quadrangularis* (Holm) from the Swedish lower Ordovician bears a fine longitudinal sculpture and all four sides of its conch are slightly concave. Much smaller *B. aetherica* sp. n. has more numerous riblets.

Occurrence: *B. deleta* was found at Králův Dvůr and at Kosov.

### *Bactrotheca aetherica* sp. n.

Pl. I, figs. 11–14

Holotype: Conch and operculum, figured herein on. pl. 1, fig. 11. LM 192.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Praha-Spořilov.
Material: 26 conchs and 3 opercula compressed in clayey shale.

Description: Small conchs with average angle of divergence of about 13 degrees (measured on ventral sides of flattened conchs). Their cross-section was subtrapezohedral as deduced from the outline of the operculum. The aperture was straight; its exact shape is unknown, except for the ventral apertural margin, which was very moderately arched backwards. The apical part of the conch was septate, with at least 8 chambers.

The sculpture consists of very fine longitudinal riblets counting about 30 per mm for the width of conch equalling 2 mm. Less prominent are faint transverse growth-lines.

Operculum of subtrapezohedral outline has well developed folds with their lateral margins converging at the apex at about 72 to 74 degrees. The apex lies at about one-fourth length of the operculum. The lateral margins of operculum are almost straight. There are no visible traces of any sculpture on the external surface. The internal surface is practically unknown. There were two cardinal processes close to the apex of unknown shape and probably two low ridges running from the bases of cardinal processes along lateral margins of the operculum.

Dimensions: The longest, almost complete specimen known measures 14.5 mm. The dimensions of the holotype: length of the conch – 11.5 mm; width of the operculum – 2.0 mm, length of the operculum – 1.4 mm.

Remarks: This species differs from all known species of *Bactrotheca* in its small size and very fine longitudinal riblets. The riblets in *B. deleta* Nov. number only about 7 per mm at the width of conch equalling 4 mm. The operculum of *B. aetherica* sp. n. has less rounded edges than that of *B. deleta* and other species.

Occurrence: *B. aetherica* sp. n. was found only in the lower layers of the Králův Dvůr Formation at Praha-Spořilov.

## *Hyolithida* SYSSOIEV, 1957

## *Hyolithidae* NICHOLSON, 1872

## *Elegantilites* MAREK, 1966

Type species: *Pugiunculus elegans* BARRANDE, 1847. Ordovician (Zahořany Formation), Bohemia.

### *Elegantilites indistinctus* (BARRANDE, 1867)

(Pl. II, figs. 1–5

1867 *Hyolithes indistinctus* BARR.; BARRANDE, p. 83, pl. 9, figs. 1–4.
1891 *Hyolithus indistinctus* BARR.; NOVÁK, p. 21, pl. 5, figs. 5–9.
1893 *Hyolithes (H.) indistinctus* BARR.; HOLM, p. 25.
1946 *H. indistinctus* BARRANDE 1867; SINCLAIR, p. 77.
1962 *Linevitus indistinctus* (BARRANDE); SYSSOIEV, p. 23.

Lectotype: Compressed composite mold of conch, figured by BARRANDE (1867) on pl. 9, fig. 4. NM L 22002.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Králův Dvůr.
Material: In addition to the lectotype, 11 conchs and 4 opercula.

Remarks: The lectotype is a strongly compressed composite mold with the ventral side up. About six septa are developed in the apical part. Ligula is asymmetric due to the deformation. The surface is practically smooth except for a few indistinct growth-lines. Only one specimen, attributed by NOVÁK (1891, pl. 5, fig. 8) to the species *indistinctus*, bears in the dorsal side a sculpture, composed of very fine, by naked eye invisible transverse and longitudinal striae, which probably represent the sculpture of the inner layer of the wall. It is difficult to confirm the specific identity of this specimen with *E. indistinctus*. The non compressed specimens from Lejškov, figured by BARRANDE (1867, pl. 9, figs. 2, 3) and by NOVÁK (1891, pl. 5, figs. 5–7) are internal molds showing indistinct transverse, irregularly spaced vaultings. The same holds for other four specimens from the same locality. The septa in the apical part of the conch are developed also in other species of *Elegantilites* (*E. benignensis*, *E. elegans*, *E. euglyphus*, *E. hejarensis*) and are not of specific importance. No traces of septa have been ascertained in undeformed internal molds from Lejškov. The cross-section of these conchs is roudedly dome-shaped, with distinctly less inflated ventral side than dorsal side. Rounded lateral edges lie approx. at two-fifths height of the conch. The shape of the cross-section is unknown in the flattened conch with septa and thus the comparison of differently preserved material is impossible. Only the smooth surface of the conch remains as specific feature of *E. indistinctus*.

The opercula belonging to the genus *Elegantilites* and most probably to this species, have distinctly narrower (sag, exsag.) cardinal shield (about one-seventh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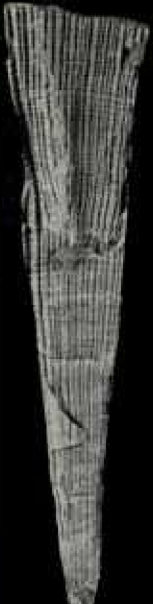
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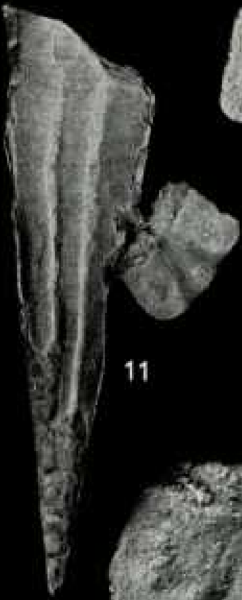
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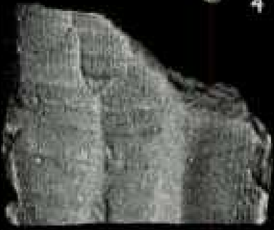
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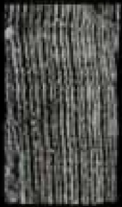
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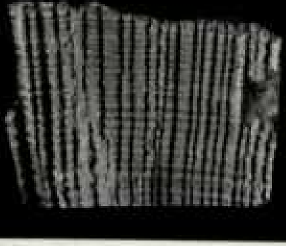
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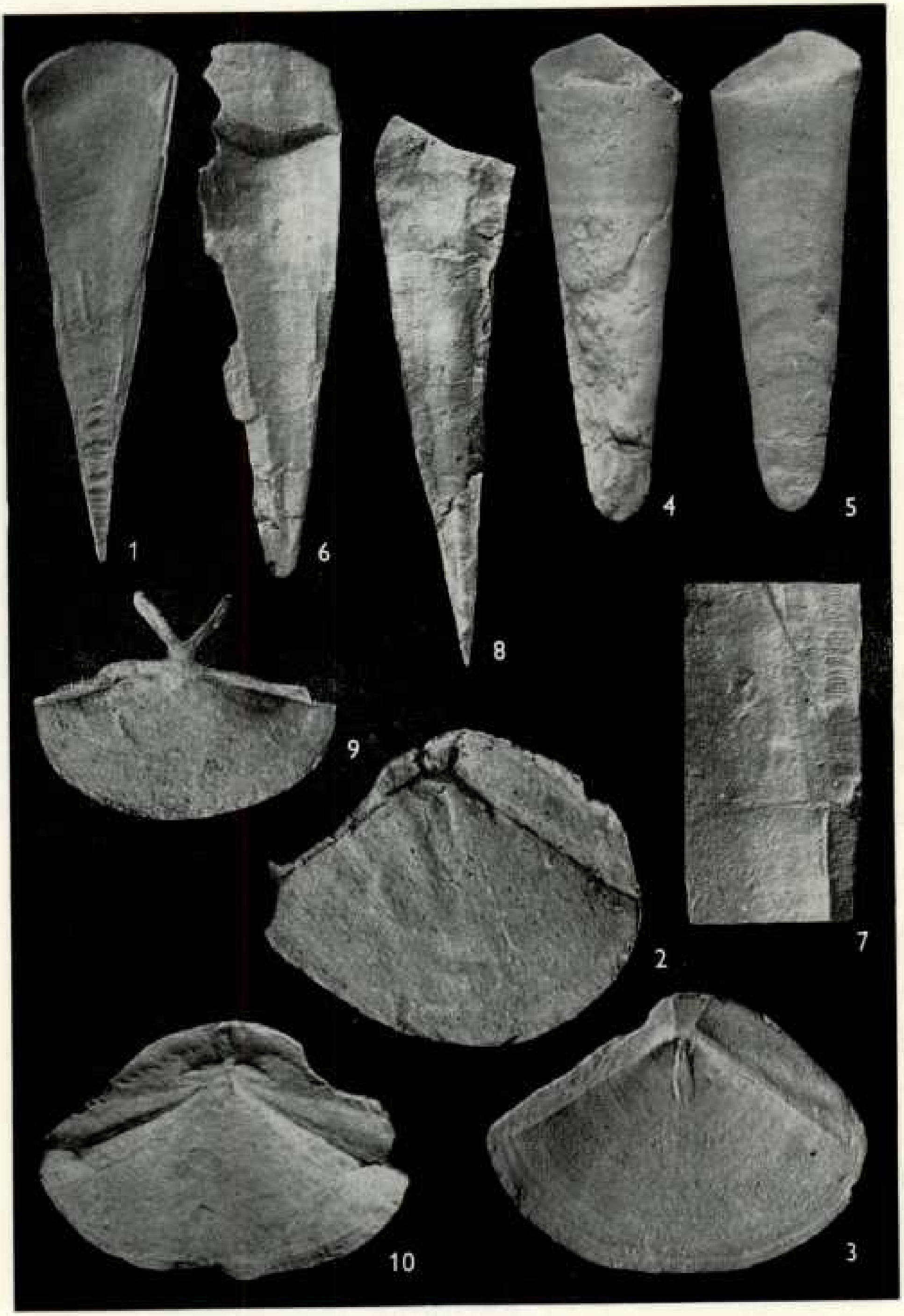
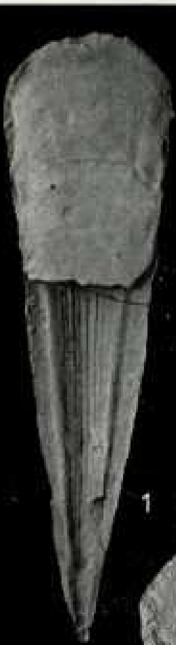
Pl. II





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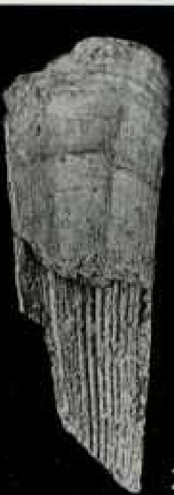

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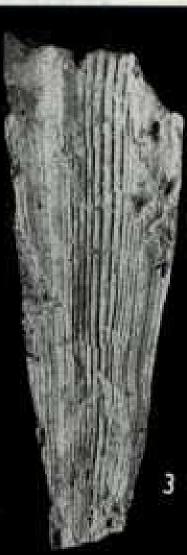

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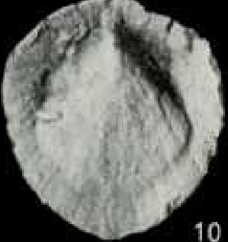
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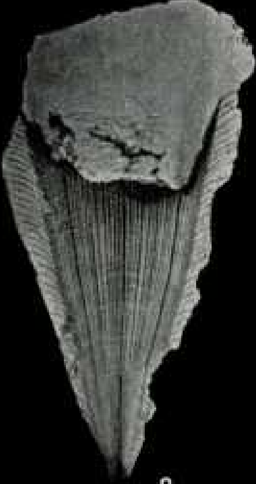
8


7

### *Sololites* Marek, 1967

Type species: *Sololites ferrigenus* Marek, 1967. Ordovician (Vinice Formation), Bohemia.

### *Sololites*? *sulcatulus* (Novák, 1891)

Pl. III, figs. 1–4

1891 *Hyolithus sulcatulus* Nov.; Novák, p. 26, pl. 3, figs. 22–24.
1893 *H.* (*H.*) *sulcatulus* Nov.; Holm, p. 25.
1946 *H. sulcatulus* Novák, 1891; Sinclair, p. 80.
1962 *Ambrolinevitus*? *sulcatulus* (Novák); Syssoiev, p. 44.

Lectotype: Originally designated herein, conch figured by Novák (1891) on pl. 3, figs. 22–24, refigured here on pl. 3, fig. 1. NM L 26000.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Králův Dvůr.
Material: In addition to the lectotype 9 incomplete conchs and 1 operculum.

Description: Conch elongate, with angle of divergence of about 15 degrees. Its cross-section is unknown. Ligula comparatively short, vaulted in a regular arch; its length attains one-third to one-quarter apertural width. The aperture was most probably orthogonal as seen from the course of obscure growth-lines.

The sculpture of the dorsal side consists of distinct longitudinal ribs with rounded ridges, numbering totally about 18–20. Novák (1891, p. 26). counted only 8 riblets on the dorsum; this mistake was undoubtedly caused by unfavourable preservation. The furrows bordering first lateral ribs along the lateral sides are deeper than the other furrows, dividing the riblets. Their distance from the lateral edges is bigger than that of the next ribs. It is probable that these deeper furrows could appear as depressions on the lateral parts of dorsal side in the cross-section of conch. Such depressions are developed in *Sololites ferrigenus* Marek and in *S.*? *clausus* Marek, 1983.

The operculum attributed to this species differs in its internal morphology from all known opercula of the Bohemian Ordovician species, but strongly resembles the operculum of *Sololites*? *clausus* Marek, 1983a (p. 5, figs. 4, 5). It has flattened and comparatively wide (exsag.) clavicles of platyclaviculate type. Similar clavicles are known in the genus *Carinolithes* Syssoiev and certain relations between *Sololites* and *Carinolithes* was already mentioned by Marek (1967).

Dimensions: The length of lectotype – 27.5 mm, the width of its aperture – 6.5 mm.

Remarks: A definite attribution of the species *sulcatulus* and *clausus* to the genus *Sololites* demands new finds in the Ordovician of the Mediterranean Province.

Occurrence: Králův Dvůr, Kosov and Liteň.

## *Pauxillitidae* MAREK

### *Decipilites* MAREK, 1975

Type species: *Hyolithes decipiens* BARRANDE, 1867. Ordovician (Králův Dvůr Formation), Bohemia.

### *Decipilites decipiens* (BARRANDE, 1867)

Pl. III., fig. 5; pl. IV., fig. 3

1867 *Hyolithes decipiens* BARR.; BARRANDE, p. 80, pl. 12, figs. 33—37.
1891 *Hyolithus decipiens* BARR.; NOVÁK, p. 16, pl. 3, figs. 25—28.
1893 *H.* (*H.*) *decipiens* BARR.; HOLM, p. 25.
1946 *H. decipiens* BARRANDE, 1867; SINCLAIR, p. 75.
1962 *Ambrolinevitus decipiens* (BARRANDE); SYSSOIEV, p. 44.
1975 *Decipilites decipiens* (BARRANDE, 1967); MAREK, p. 238, pl. 1, figs. 1—5.

Lectotype: Originally designated by MAREK (1975), conch figured by BARRANDE (1867) on pl. 12, figs. 33, 34. NM L 13561.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Kosov.
Material: 27 conchs, 15 opercula.

Remarks: The original description of this species, given by Barrande was completed by NOVÁK (1891) and by MAREK (1975).

Occurrence: Kosov, Karlík, Zadní Třebaň, Praha-Velká Chuchle, Praha-Nusle (Jezerka). The occurrence of this species in the Vinice and Zahořany Formation (according to BARRANDE and NOVÁK) was not proved.

### *Recilites* MAREK, 1967

Type species: *Hyolithes solitarius* BARRANDE, 1867. Ordovician (Zahořany Formation), Bohemia.

### *Recilites*? aff. *poeta* MAREK, 1967

Pl. III, figs. 6—8

Material: 3 conchs and 2 opercula.

Description: The cross-section of elongate conch is unknown, the angle of divergence approximately 15 degrees. Ligula regularly arched, attains the length of one-third to one-fourth of apertural width.

The sculpture of conch is composed of fine but distinct longitudinal, not quite equidistant riblets, spaced less densely on the dorsal side, where they count about 5 per mm; their number on the ventral side is 7—8 per mm. This side bears also not very distinct fine vaultings, arched anteriorly, copying the margin of ligula. Nothing is known about the presence of transverse sculpture on the dorsal side.

The opercula attributed to this species are preserved as composite molds and their outline is deformed in a certain degree. The operculum was most probably monoclaviculate and the clavicles were thin. The shape of the cardinal processes is unknown except for their bases which are thin and diverge at an angle of 95 to 105 degrees.

The cardinal shield is very narrow in the axial line. The ratio of its length (sag.) to the length of the conical shield is about 1 : 10. The same ratio in *R.? poeta* is about 1 : 4 to 1 : 5.

The surface is sculptured by fine, not very distinct radial riblets.

Dimensions: The maximum length of the conch exceeded 15 mm. The width of the figured conch'(LM 205) measures 5.4 mm at the aperture.

Remarks: This species differs only slightly from *R.? poeta* MAREK occurring in the upper layers of Zahořany Formation and in Bohdalec Formation. The difference is in the spacing of riblets on the conch and in a different ratio of the length of cardinal shield to the length of conical shield of operculum. The scarcity and poor preservation of the material do not allow yet the specific separation of both taxa. Another problem poses the generic appurtenance of these taxa. Monoclaviculate operculum is not yet known in the representatives of the family *Pauxillitidae*. It is probable, that *R.? poeta* and *R.?* aff. *poeta* belong to a new separate genus of uncertain affinities within *Hyolithida*. The material available is unsufficient for solving this problem.

Occurrence: Praha-Spořilov, Kosov.

### *Leolites* MAREK, 1967

Type species: *Leolites cognatus* MAREK, 1967. Ordovician (Zahořany Formation), Bohemia.

### *Leolites paucicostatus* sp. n.

Pl. III, fig.s. 9, 10; pl. IV., fig. 5

Holotype: Conch, figured on pl. 3, fig. 10. LM 209.
Stratum typicum: Králův Dvůr. Formation.
Locus typicus: Praha-Spořilov.
Material: 5 conchs and 3 opercula.

Description: Conchs of small size (about 5—8 mm) with comparatively big angle of divergence (30—35 degrees). Ligula of semicircular outline attains the length of a half apertural width. The shape of the aperture could not be ascertained due to pressure deformation of conch.

The sculpture of the dorsal side consists of 11—13 ribs, the detailed morphology of which is unknown. The ventral side practically smooth.

The operculum is polyclaviculate and bears three pairs of main clavicles and 3—5 additional clavicles, radially arranged on the central part of operculum. The morphology of cardinal processes and the shape of cardinal shield are unknown as well as the surface sculpture.

Dimensions: The length of holotype — 6.5 mm, the width of aperture — 2.6; the length of specimen LM 208 — 4.5 mm.

Remarks: The Berounian species *Leolites cognatus* Marek, known from the Vinice and Zahořany Formations differs clearly in more closely spaced longitudinal riblets. The operculum of this species bears a greater number of additional clavicles (6—9).

Occurrence: Praha-Spořilov, Praha-Nusle (Jezerka).

### *Mediolites* gen. n.

Type species: *Mediolites sporilovensis* sp. n. Ordovician (Králův Dvůr Formation), Bohemia.

Diagnosis: Pauxillitid hyoliths with sparsely spaced longitudinal riblets on the dorsal side of considerably elongate conchs with semicircular ligula.

Operculum tetraclaviculate, with four pairs of radially arranged narrow clavicles. Clavicles of the 2nd to 4th pairs slightly arched and increasing in length, so that the clavicles of the 4th pair are the longest. Surface bears radial riblets.

Remarks: *Mediolites* gen. n. shows closest relations to *Leolites* Marek, which has a radially ribbed polyclaviculate operculum. *Pauxillites* Marek from the Šárka and Dobrotivá Formations has triclaviculate opercula with comparatively robust clavicles and smooth surface. The opercula of *Recilites* Marek bear radial sculpture but only three pairs of clavicles are developed on their internal surface.

Occurrence: Ordovician (Kralodvor), Bohemia.

Species: Only *M. sporilovensis* sp. n.

### *Mediolites sporilovensis* sp. n.

Pl. IV., figs. 1, 2

Holotype: By monotypy, conch with disarticulated operculum, figured here on pl. 4, fig. 1—2.
Stratum typicum: Králův Dvůr Formation.
Locus typicus: Praha-Spořilov.
Material: Only holotype.

Description: Narrow conch with angle of divergence of about 13 degrees has a comparatively long ligula, the length of which attains one-third to one-half apertural width. The type of aperture and the shape of cross-section are unknown due to compression.

The surface of the dorsal side bears sparsely spaced longitudinal ribs numbering about 12. The ventral side is covered only with indistinct growth-lines copying the margin of ligula.

Tetraclaviculate operculum bears on the surface of conical shield fine radial riblets numbering 11–13 per mm on its margin. Cardinal shield and processes unknown. The internal surface is characterized by four pairs of narrow clavicles, of which the basal (main) pair is straight and wider (exag.) than the other three, slightly arcuate pairs; the clavicles of the fourth pair are the longest.

Dimensions: The conch of holotype measures 9.3 mm.

Remarks: See the diagnosis of the genus.

Occurrence: Praha-Spořilov.

### Familia incerta

### *Gompholites* MAREK, 1966

Type species: *Hyolithes cinctus* BARRANDE, 1867. Ordovician (Šárka Formation), Bohemia.

Remarks: The external and internal morphology of the conch and operculum of *Gompholites* differs substantially from all hitherto known Ordovician genera of the family *Hyolithidae*. In my opinion, this genus is the representative of a separate family within the oder *Hyolithida*, comprising but one genus. This is the main reason why I hesitate to establish the new family.

The occurrence of *Gompholites* was ascertained outside Bohemia also in the Ordovician of France (MAREK, 1975, species not established) and Morocco (MAREK 1983).

### *Gompholites* sp. n.

Pl. IV, figs. 6, 7

Material: 1 conch and 7 opercula, all flattened in shale.

Description: The angle of divergence of compressed conch makes about 17 degrees. The cross-section of conch and the exact shape of aperture are unknown. The ligula is moderately arched, not very long; its length attains only about one-fourth of apertural width. Apertural sinuses strongly rounded.

The sculpture is known only on the ventral side of conch. It consists of fine growth-lines of unequal prominence numbering about 10 per mm. Anteriorly arched growth-lines copy the margin of ligula and are more distinct close to the aperture.

The operculum of subcircular outline is monoclaviculate. The bases of cardinal processes seem to be more or less rounded. The lateral sinuses are comparatively deep and broad.

The sculpture of operculum consists of fine concentric growth-lines.

Dimensions: The length of conch = 31 mm. Dimensions of three opercula in mm:

| | | | | |
|---|---|---|---|---|
| Width: | 4.3 | 4.1 | 3.8 | 4.7 |
| Length: | 3.9 | 3.7 | 3.7 | 3.8 |

Remarks: This species is insufficiently known. Compressed opercula do not differ from those of possibly related Berounian species *Gompholites striatulus* (Barr.), when preserved in the same mode. However, the sculpture of conch in the last mentioned species is more coarse than in *Gompholites* sp. n. *C. cinctus* (Barr.) from the Llanvirn attains a smaller size and its sculpture is formed by fine but distinct transverse riblets and irregularly spaced imbrications. Several species of *Gompholites* described in open nomenclature from the Moroccan Ordovician (Marek 1983) are too poorly preserved for any comparison. *Gompholites* sp. n. is the stratigraphically youngest representative of the genus *Gompholites* as yet known.

Occurrence: Kosov.

### *Raitilites* gen. n.

Type species: *Raitilites metallicus* sp. n. Ordovician (Králodvor), Bohemia.

Diagnosis: Conch of low subtrigonal cross-section with sharply expanded lateral edges. Ventral side slightly convex with broad shallow grooves along lateral edges of ventral side. Aperture distinctly oxygonal.

Sculpture of dorsal side consists of distinct longitudinal riblets except for its lateral parts, which bear transverse terrace lines. Longitudinal ribs are crossed by transverse growth-lines.

Operculum unknown.

Remarks: It is difficult to compare *Raitilites* gen. n. with other Ordovician hyolithid genera without knowing the operculum. Longitudinal ribs of dorsal side resemble somewhat the sculpture of *Sololites*. Oxygonal type of aperture and grooves on ventral side indicate the possible appurtenance of this genus to the family *Pauxillitidae*. Most significant features of *Raitilites* are flat lateral margins with "terrace lines".

Occurrence: Ordovician (Kralodvor), Bohemia.

### *Raitilites metallicus* sp. n.

Pl. IV, fig. 8

Holotype: By monotypy, conch figured herein on pl. 4, fig. 8. LM 214.

Stratum typicum: Králův Dvůr Formation.

Locus typicus: Praha-Pankrác (Rajtknechtka).

Material: Only holotype, fragmentary steinkern with external mold of dorsal side.

Description: Conch of flattened subtrigonal cross-section with very sharp lateral edges. The angle of divergence about 35—40 degrees, the w/h index very approximately 4.3. Ventral side very slightly convex, almost flat. On the ventral anterior part of the steinkern, two broad shallow grooves are developed, each along the lateral edge of the conch. Flanks of the dorsal side slightly inflated, meeting at a rounded edge. Aperture oxygonal as seen from adaperturally arched growth-lines.

The sculpture of the dorsal side consists of about 41 distinct longitudinal riblets. Three riblets are more pronounced: one in the median axis and two closer to the lateral edges. The flattened lateral parts of conch are sharply divided from its inflated longitudinally ribbed part and bear a different sculpture. This is formed by transverse and somewhat anteriorly directed lines, resembling the terrace lines in trilobites. These lines are slightly adaperturally arched.

The operculum is unknown.

Dimensions: The length of holotype measures 9.5 mm.

Remarks: The morphology and sculpture of this species is unique among hyolithids and any comparison with other Ordovician species is impossible. It seems that it was confined to a specific environment.

Occurrence: *Raitilites metallicus* sp. n. was found in the so-called "Podolí ore" horizon in the site called Rajtknechtka in Praha-Podolí. This horizon forms the base of the Králův Dvůr Formation.

### *Hyolithida* gen. et sp. n.

Pl. IV, fig. 10

Material: 1 operculum at 1 conch probably belonging to it.

Description: Small comperessed and smooth conch without any characteristic feature except a distinct ligula.

The operculum is monoclaviculate with parabolically elongate anterior margin of conical shield. The shape of clavicles and cardinal processes unknown. The cardinal shield is narrow and protracted in its median axis into a short and blunt tip, indicating a probable presence of a keel on the dorsal side of conch.

Dimensions: The length of conch 8.8 mm; length of operculum 1.9 mm, its width 1.7 mm.

Remarks: Owing to insufficient material, the taxonomical evaluation of the remains is impossible. The shape of operculum indicates that this taxon could be tentatively attributed to *Carinolithes* SYSSOIEV (see MAREK 1967, text-fig. 26).

Occurrence: Lejškov.

*K tisku doporučil R. Prokop*

*Přeložil autor*

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## Explanation of plates

The specimens have been coated with ammonium chloride. Unretouched photographs were taken by the author.

LM – author's collection housed provisionally in the Institute of Geology and Geotechnics of the Czechoslovak Academy of Sciences, Praha. NM L – collections of the National Museum (Natural History), Praha.

### Pl. I

*Circotheca neptis* sp. n.

1, 2. Holotype; incomplete steinkern of conch with remain of shell; 1 – dorsal view; 2 – lateral view, ×7. Praha-Kačerov. LM 186.

*Nephrotheca ruderalis* sp. n.

3. Conch; ventral side of steinkern, ×6.4. Praha-Kačerov. LM 187.
4. Holotype; conch, latex cast of ventral side, ×6.4. Praha-Kačerov. LM 188.

*Panitheca* aff. *collector* Marek, 1967

5. Conch; anterior half shows external mold of ventral side, posterior half shows internal mold of dorsal side, ×4. Kosov. LM 189.
6. Same specimen; detail of sculpture (external mold), ×16.
7. Fragment of conch; external mold of dorsal side showing zig-zag sculpture, ×12.5. Kosov. LM 190.

*Bactrotheca deleta* Novák, 1891

8, 9. Lectotype; external mold of conch; 8 — almost complete conch, × 4.6; 9 — detail of sculpture close to the aperture, × 8. Králův Dvůr. NM L 26105.

10. Operculum most probably belonging to this species; internal mold, × 13. Kosov. LM 191.

*Bactrotheca aetherica* sp. n.

11. Holotype; conch with displaced operculum; external mold of ventral side, × 7.6. Praha-Spořilov. LM 192.
12. Ditto; detail of sculpture at the aperture, × 13.5.
13. Ditto; external mold of operculum, × 16.5.
14. Another operculum; external mold, × 11. Praha-Spořilov. LM 193.

*Nephrotheca* ? sp. n.

15. Conch; ventral side, × 3.3. Lejškov. NM L 25103.

### Pl. II

*Elegantilites indistinctus* (Barrande, 1867)

1. Lectotype; composite mold of conch showing ventral side with septa in apical part, × 2.7. Králův Dvůr. NM L 22002. Orig. Barrande, pl. 9, fig. 4.
2. Operculum; internal mold, × 5.3. Kosov. LM 194.
3. Operculum; negative of composite mold, × 5. Kosov. LM 195.

4, 5. Conch, probably belonging to this species; internal mold; 4 — dorsal side; 5 — ventral side, × 2.8. Lejškov. NM L 22001. Orig. Barrande, pl. 9, figs. 2, 3.

*Joachimilites viridis* sp. n.

6, 7. Holotype, conch; 6 — compressed specimen showing external mold of dorsal side and internal mold of ventral side in the apertural part, × 3; 7 — detail of sculpture, × 5.5. Kosov. LM 197.

8. Conch; dorsal side, × 2.3. Kosov. LM 199.
9. Operculum; composite mold showing clavicles and cardinal processes, × 10. LM 200.
10. Operculum; composite mold, × 7.4. Kosov. LM 201.

### Pl. III

*Sololites ? sulcatulus* (Novák, 1891)

1. Lectotype; almost complete conch showing external mold of ventral side in its anterior part and external mold of dorsal side in its posterior part, × 3. Králův Dvůr. NM L 26000. Orig. Novák, pl. 3, figs. 22—24.
2. Incomplete conch, showing similar features, × 3.5. Kosov. LM 202.
3. Incomplete conch; external mold of dorsal side, × 3.5. Kosov. LM 203.
4. Operculum; composite mold most probably belonging to this species, × 7.8. Kosov. LM 204.

*Decipilites decipiens* (Barrande, 1867)

5. Conch in ventral view; posterior part shows sculpture of dorsal side, × 4.5. Kosov. LM 146.

*Recilites* ? aff. *poeta* Marek, 1967

6. Conch; ventral side with distinct longitudinal riblets. Sculpture of dorsal side formed by less closely spaced riblets visible in the right posterior part of specimen, × 4.8. Praha-Spořilov. LM 205.
7. Operculum; composite mold, × 9. Kosov. LM 206.
8. Operculum; composite mold, × 13. Kosov. LM 207.

*Leolites paucicostatus* sp. n.

9. Conch in ventral view showing external mold of dorsal side with longitudinal ribs, × 11. Praha-Spořilov. LM 208.
10. Holotype; composite mold of conch showing the sculpture of dorsal side, × 10. Praha-Spořilov. LM 209.

Pl. IV

*Mediolites sporilovensis* sp. n.

1. Holotype; composite mold of conch; 1a — counterpart, × 7.6. Praha-Spořilov. LM 210.
2. Holotype; displaced operculum belonging to the conch, fig. 1, × 13. Praha-Spořilov. LM 210.

*Decipilites decipiens* (BARRANDE), 1867)

3. Operculum; composite mold, × 8. Kosov. LM 150.

*Leolites paucicostatus* sp. n.

4. Conch; dorsal side, × 11. Praha-Spořilov. LM 211.
5. Operculum; internal mold, × 14. Praha-Nusle (Jezerka). LM 212.

*Gompholites* sp. n.

6. Conch; dorsal side, × 3.1. Kosov. NM L 26104.
7. Operculum; composite mold, × 8. Kosov. LM 213.

*Raitilites metallicus* sp. n.

8. Holotype; external mold of dorsal side of conch with preserved internal mold of ventral side in the apical area, × 7. Praha-Michle (Rajtknechtka). LM 214.
9. Ditto; detail of sculpture, × 11.

*Hyolithida* gen. et sp. n.

10. Operculum; composite mold, × 18. Lejškov. LM 215.

## Hyoliti králodvorského souvrství českého ordoviku

(*Résumé anglického textu*)

Ladislav Marek

Předloženo 6. října 1986

V práci jsou popsány všechny dosud známé druhy hyolitů z králodvorského souvrství českého ordoviku. Podkladem pro studium byl především nově nasbíraný materiál, na jehož základě bylo možno v králodvorském souvrství zjistit výskyt rodů *Circotheca*, *Nephrotheca*, *Panitheca*, *Bactrotheca*, *Elegantilites*, *Joachimilites*, *Gompholites*, *Leolites*, *Decipilites*, *Recilites* ? a pravděpodobně i rodu *Sololites*. Byly stanoveny dva nové rody *Mediolites* gen. n. a *Raitilites* gen. n. a 7 nových druhů. Celkem je z králodvoru známo v současné době 15 druhů, z toho čtyři jsou v otevřené nomenklatuře.

### Хиолиты кралодворской свиты ордовика Чехии

В представленной работе описаны все известные до сих пор виды хиолитов из кралодворской свиты ордовика Чехии, изученные, главным образом, на основании вновь собранного материала, благодаря которому в кралодворской свите можно было установить наличие родов: *Circotheca*, *Nephrotheca*, *Panitheca*, *Bactrotheca*, *Elegantilites*, *Joachimilites*, *Gompholites*, *Leolites*, *Decipilites*, ? *Recilites* и, по всей вероятности, тоже рода *Sololites*. Определены два новых рода: *Mediolites* gen. n., *Raitilites* gen. n. и 7 новых видов. Из кралодворской свиты в настоящее время известно 15 видов, в том числе 4 вида, находящиеся в открытой номенклатуре.

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# Fauna from the limestones at the Frasnian/Famennian boundary at Mokrá (Devonian, Moravia, Czechoslovakia)

## Fauna z vápenců při hranici frasn/famen v Mokré (devon, Morava, Československo)

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Abstract: The reef-building fauna of the Mokrá section extincted in the upper part of the conodont Palmatolepis crepida Zone. Into the lower Famennian, penetrated namely less diversified euryfacies species. The decrease in the diversity is being associated with the Kellwasser eustatic and climatic events proved today, from a general viewpoint, from the mid-levels of the Palmatolepis gigas Zone up to its top (Walliser 1985, 1986) and supposed up to the mid-levels of the Palmatolepis triangularis Zone (the so-called Crickites Event — Kalvoda 1986). In the section, the Frasnian/Famennian boundary is restricted to the gap between the intervals I and II. Under the gap, occur *Scoliopora kaisini* (Lecompte) and the foraminifers *Nanicella* ap. — species found so far in Moravia exclusively up to the upper limit of the conodont Palmatolepis gigas Zone, while above the gap lower Famennian *Labechia cumularis* Yavorski and *Syringopora volkensis* Tschernyschev appear already. The gap very likely involves the current critical interval of the Fransian/Famennian boundary corresponding to the lower third of the Palmatolepis triangularis Zone. By contrast, the prominent lithologic change between the Macocha and Líšeň Formations (above int. IV) and extinction of sessile benthos (by 3 to 5 cm lower in the section) do not lack a biostratigraphic record — both the underlying and overlying levels provide autochthonous conodonts of the upper part of the Palmatolepis crepida Zone.

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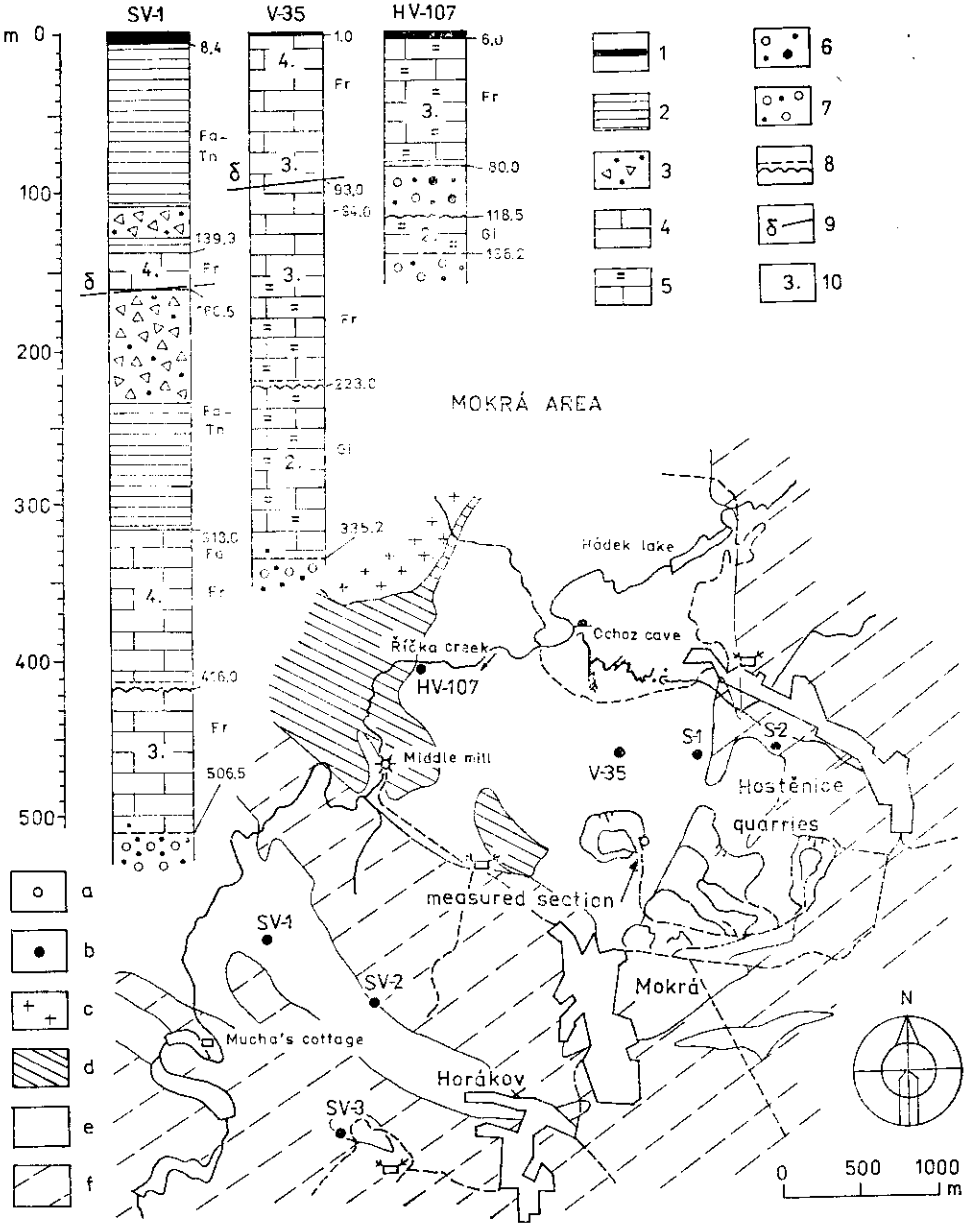
### Introduction

The section measured stretches in the entrance part of the Western Quarry at Mokrá (comp. fig. 1). It lies at the transition of the Macocha Formation (composed mainly of carbonate buildups) into the overlying post-reef facies of variegated carbonate sequences which refer to the Líšeň Formation. Geologically, the section



1. Sketch map of topography and geology in the environs of the Mokrá Quarries. Location of more significant boreholes is plotted, boreholes mentioned in the paper are schematized
*a* – measured section, *b* – location of the borehole, *c* – Brno Massif granodiorite, *d* – undistinguished Devonian siliciclastic rocks (the basal clastic formation), *e* – undistinguished Devonian and lower Carboniferous carbonate sediments (Macocha and Líšeň Formations), *f* – Lower Carboniferous sediments of the Culm Facies, undistinguished (Březina Shales, Rozstání and Myslejovice Formations)

is situated in the southern closure of the Moravian Karst in general described by DVOŘÁK (1961) and DVOŘÁK et al. (1987).

The first evaluation of the section situated at the transition of both mentioned formations was given in FRIÁKOVÁ et al. (1985). Then followed a new description of its rugose and tabulate corals (HLADIL 1987, GALLE 1987), microfacies of the individual layers and relations to the surrounding deposition. The data on the section, therefore, had to be newly summarized. The paper was prepared within the framework of the IGCP Project No. 216 "Global Biological Events".

The authors are indebted for useful advice to J. Crha and V. Kudělásek from the Geological Exploration, n. e. and to all the authors referred to in this paper.

## General characteristics of the sequence

The Macocha Formation (built preferably of Devonian carbonate buildups) in the space of the Mokrá Quarries started to form later than elsewhere in the Moravian Karst. The Macocha Formation as a stratigraphic unit was defined by ZUKALOVÁ - CHLUPÁČ (1982). It involves dark heavy-bedded limestones of the lagoonal facies — the Lažánky Limestones — and the light-coloured, comparatively massive Vilémovice Limestones.

The earliest evidenced layers of the Macocha Formation carbonate deposits were drilled by boreholes HV-107 located 1.8 km NW of the measured section in the Mokrá Western Quarry (comp. fig. 1) and V-35 roughly 600 m to the NNW of the section (comp. fig. 1). They are Givetian in age and refer to the 2nd megacycle rocks (HLADIL 1986). According to the borehole HV-107, the upper part of the 2nd megacycle is eroded down to the middle or lower Givetian banks with *Amphipora ramosa* (PHILLIPS) and above the eroded surface there is a layer of polymict siliciclastic sediments. Silicified fragments of biohermal limestones of the upper part of the 2nd megacycle [with *Caliapora battersbyi* (MILNE EDWARDS et HAIME)] redeposited even to the 3rd megacycle lower Frasnian limestones in the Old Mokrá Quarry, approx. 600 m to the S of the measured section (comp. fig. 1). The erosion events within the upper part of the Macocha Formation are evidenced also by silicified fragments of the 3rd megacycle limestones (with *Actinostroma crasse-*

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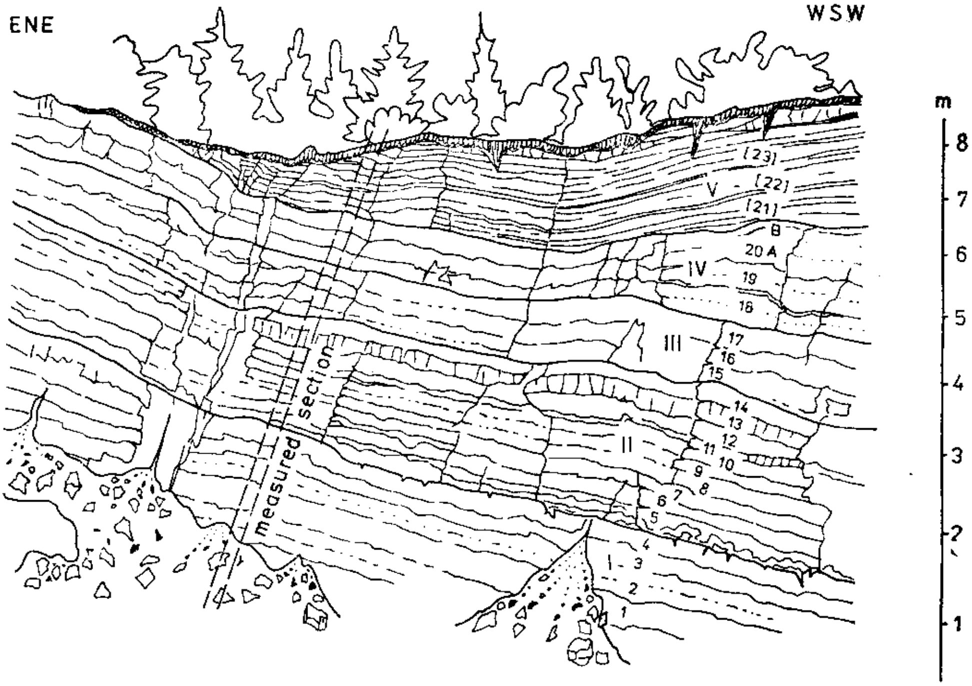
*1* — Quaternary deposits and reworked Tertiary residua, *2* — bank facies of micrite and detrital limestones of the Líšeň Formation (Famennian—Tournaisian), *3* — breccia facies of the Líšeň Formation (Famennian—Tournaisian), *4* — light boundstones of the Macocha Formation = Vilémovice Limestone (Frasnian—Famennian) and associated layers, *5* — dark boundstones, packstones, and associated layers = Lažánky Limestone (Givetian—Frasnian), *6* — polymict sandstones and conglomerates of Devonian age, *7* — Devonian quartz sandstones and conglomerates, *8* — levels of nondeposition and erosion, *9* — thrust dislocations (roughly from S to N), *10* — number of the microfacially limitable cycle in the Macocha Formation *pilatum* Lecompte), which occur in the 4th megacycle rocks with *Nanicella*? sp. and *Multiseptida* sp., E of a grinder, some 750 m to the SE of the measured section.

An interesting borehole was situated 2.5 km WSW of the measured section (SV-1 Horákov drilled by the Geological Exploration, n. e.) and reached more than 500 m in depth. It revealed that the beds strike subhorizontally but the Macocha and Líšeň Formations tectonically repeat (see the sketch on fig. 1). The lower of the both drilled Macocha Formation sequences is 188.5 m thick (318.0–506.5 m). According to the stromatoporoid fauna, the onset of the limestone deposition is confined to the middle Frasnian levels. At the base the limestones contain a sandy admixture, biohermal levels are separated by micritic limestones with cryptalgal structures and gastropods. The boundary between the 3rd and 4th megacycle rocks is situated at the depth of 416.0 m where, after some claystone interbeds, deposit darker limestones (colour N3 to N4 on Munsell colour system). The uppermost parts of the Macocha Formation are of biosparite limestones comprising frequent micritized grains and fragments of *Amphipora tschussovensis* Yavorski and *Am. moravica* Zukalová. E. Možíšová (Geological Exploration, n. e., Brno branch; personal communication 1986) reports the conodont fauna of the Palmatolepis crepida Zone at a 318.0 m depth. The immediately overlying layers are built of intrasparites comprising coated grains free from sessile benthos. They are light-coloured, devoid of any clay admixture, comparatively massive, and in places contain thick-walled shells of unidentified pelecypods up to 8 cm in diameter. The limestones provide the conodont fauna of the Zones Palmatolepis marginifera (depth 313.0 m) to Palmatolepis postera postera (depth 311.0 m) – E. Možíšová. From the biofacies viewpoint, of this lower Macocha Formation sequence (borehole SV-1 Horákov) the assemblage of a flat, gently inclined ramp is the most typical (*Scoliopora denticulata rachitiforma* Hladil, *Amphipora tschussovensis* Yavorski, foraminifer *Multiseptida* sp., in regression levels the algae *Moravamminidae* indet. and *Umbelaceae* indet.).

The upper sequence of the Macocha Formation drilled by the SV-1 borehole (depth 139.3 to 160.5 m) has a different character. The sequence belongs to the upper levels of the formation, to the 4th megacycle. Rudstones and floatstones with stachyods are more frequent here. The coral fauna of the Frechastraea pentagona – Temnophyllum Zone [*Marisastrum* sp. – depth 142.6 m, *Frechastraea pentagona* (Goldfuss) – depth 143.7 m, *Piceaphyllum* sp. – depth 153.9 m] was proved. The conodont fauna detected in the uppermost part of the sequence, at a 140.0 m depth, indicates the Frasnian/Famennian boundary levels (E. Možíšová – personal communication). The limestones contain ubiquitous algae *Renalcis* sp. and they have the character of reef banks.

The upper part of the Macocha Formation (the 4th megacycle) is exposed immediately in the space of the Mokrá Quarries, whereas exposures of the earlier, 3rd megacycle layers are restricted only to the southern part of the Central Quarry and the Old Quarry near Mokrá (about 600 m s. of the measured section). Limestones of the 4th megacycle contain fauna typical of ramps and buildups delimited by non-reef shoals — *Scoliopora denticulata rachitiforma* Hladil, *Amphipora tschussovensis* Yavorski and *Multiseptida* sp. In the space of the quarries, the proximal part of the buildups spatially close to the basin facies is exposed. This is evidenced by a sporadic occurrence of radiolarians in the section (fig. 3). The sequence of strata at the transition of the Macocha Formation into the overlying Líšeň Formation is roughly comparable in different sections within the Mokrá Quarries, unless it is disrupted by disharmonic polyphase deformation. The NNE-SSW stretching elevation exposed in the western face of the Central Quarry is the only exception. Part of the lower Famennian layers of the Macocha Formation is remarkably reduced in this space where Neptunian dykes have developed filled with internal sediment and biosparite layers containing large cross-cuts of *Cribroshaeroides* sp. and fragments of *Amphipora tschussovensis* Yavorski.

The section measured is situated in tectonically undisturbed space, at the Western Quarry entrance (comp. figs. 1, 2). Here, the beds dip SE at about 20°. In the uppermost part of the Macocha Formation, cycles attaining a metre order thickness mark the section face. The darker layers scale N3 to N4 on Munsell colour system, the lighter N5. With respect to the cycles, intervals I—IV were established. Interval I involves beds 1—4, interval II — 5—14, interval III — 15—17, and int. IV — 18—20 (comp. figs. 2, 3).



2. Scheme of the measured exposure, state — November 1984, Mokrá — Western Quarry

At the upper limit of interval I and less intensively in intervals II and III, refilled vugs and fissures have developed, whereas in the uppermost part of interval IV they do not appear any more. Here, the sessile benthos disappears inside the bed 20, between the thicker, lower part 20A and the upper one 20B. The lower part of the bed is composed of biosparite with stromatoporoid coenostea "in situ" or broken and transported. The upper part of the bed is formed of fine biosparite with admixed micrite, abundant conodonts, unidentified crushed phosphatic skeletons (fish carapaces?) and columnals of small crinoids. The suture between the both layers observable on the polished section is horizontal, without erosion structures, modified only with a 2 mm amplitude stylolite, and the supposed dissolution loss of the carbonate material is 3—5 mm. Both parts of the bed 20 contain conodonts of the upper part of the Palmatolepis crepida Zone. The lower one comprises minute elements produced by conodontoforids under less favourable conditions, while the upper contains bigger, excellently created elements. The conodont fauna is given in tabs. 1 and 2. Lithologic and biotic indications point to an abrupt change of the environment that led to the extinction of sessile benthos.

The interval V refers already to the Líšeň Formation. It starts with the deposition of laminite with alternating micrite and biosparite laminae, in places cross-bedded. The above biointrasparite layer contains sporadic clayey and micrite admixtures, frequent cephalopod shells (often straight, conical, partly of Bactrites type), and numerous crinoid columnals. The rest of the interval consists of thinner layers showing fine horizontal bedding where clayey, fossiliferous micritic limestone prevails, often having a nodular structure.

Similarly also interval VI begins with a thin laminite layer and continues with a layer of biosparite and in the higher-situated parts with nodular micritic limestones.

A conspicuous gap accompanied by erosion is located above interval VI. Shallow erosion depressions are filled with irregular layers of encrinite (interval VII). Interval VI includes the fauna of the uppermost part of the conodont Palmatolepis crepida Zone, at the base of interval VII dominate conodonts of the Palmatolepis marginifera Zone and foraminifers of the Septatournayella rauserae — Septabrunsiina Zone. Conodonts of the Palmatolepis rhomboidea Zone do not occur (comp. tab. 2, fig. 3).

With the advancing exploitation of the Western Quarry, the beds 16, 19, and 20 contained more clay minerals. The rising amount of the clay material showed still more tiny, bulbous, joint coenostea of *Habrostroma* cf. *incrustans* (HALL et WHIFIELD).

## Microfacies characteristics of the Macocha Formation layers in the measured section (Western Quarry, Mokrá)

The microfacies characteristics of the layers results from the evaluation of a set of thin sections, etched fragments, and insoluble residua after dissoving in acetic acid.

The layers of the measured section are numbered from zero either way, described from the base to the top:

—3: laminated micrite with laminae of finely crystalline limestone, colouring up to N6. Originally most probably algal laminae. The sediment contains small complete ostracod shells. Thickness 15 cm.

—2: laminated linestone built of alternated biosparite laminae, with fragments of Amphipora stems and ostracods, and laminae of originally clastic micrite. The laminae often wedge out laterally. Thickness 23 cm.

—1: Biomicritic limestone with *Amphipora moravica* ZUKALOVÁ and *Am. hanimedi* YAVORSKI. There occur irregularly swelled layers of fossiliferous micrite with algae *Issinella sp.*

0: Biomicritic limestone with transitions into biointramicrite with fine horizontal bedding. At the base, there is a thin biosparite layer, in the upward direction micrite prevails. Thalli of the algae *Issinella* sp., *Moravamminidae* indet. are involved. In the uppermost part, the rock passes into biosparite with scattered *Multiseptida* sp. and *Nanicella* sp.

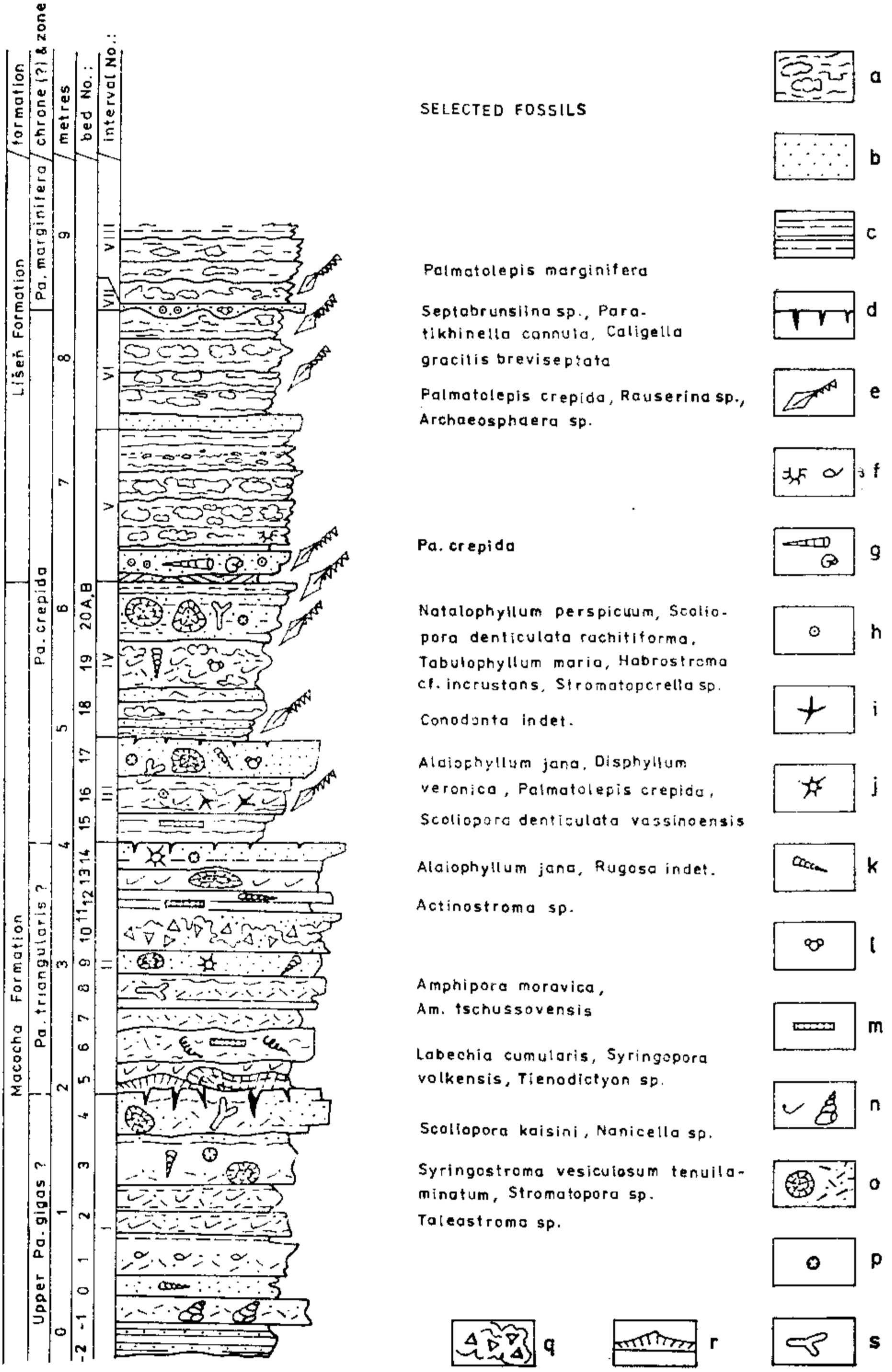
1: Biomicritic limestone with well-developed horizontal bedding. Some layers possess even 2 cm long fragments of *Amphipora moravica* ZUKALOVÁ, other contain finely crushed Amphipora tissues and brachiopods with their spines. Ostracods and sponge spicules are common. Thickness 32 cm.

2: Biomicritic limestone with *Amphipora moravica* ZUKALOVÁ and *Am. hanimedi* YAVORSKI is interlain with wedging out laminae comprising crushed Amphipora tissues. Thickness 40 cm.

3: Inhomogeneous bank formed namely of biosparite with larger fragments of stromatoporoids and corals floating within. Certain parts are bound with algae and stromatoporoids. The presence of *Taleastroma* sp., *Syringostroma vesiculosum tenuilaminatum* ZUKALOVÁ and other species has been ascertained (see table 1). The insoluble residue shows an increased amount of isometric quartz grains, up to 0.5 mm in diameter. Thickness 45 cm.

4: Biosparite and biosparrudite limestone, in places with pocket-like fillings of a micrite sediment. Bioclasts are intensively micritized. *Stachyodes lagowiensis* GOGOLCZYK and *Scoliopora kaisini* (LECOMPTE) are present. In places, we can observe complicated stromatactises with originally fibrous rims encircling the stachyods. Like the vadose silt fillings of the intercoral spaces, they acquire a brownish colour when pigmented with Fe-oxides. The colouring may result from the subaeral diagenesis when the bank surface emerges before the next deposition. Thickness 35 cm.

5: Framestone built of complicated sheets of the corals *Syringopora volkensis* TCHERNYSCHEV and *Aulostegites* sp. The sheets are built in part also by the stromatoporoids *Tienodictyon* sp. and *Labechia cumularis* Yavorski. The intercoral spaces are filled with carbonate claystones or micritic limestones with *Moravamminidae* indet., rarely also *Umbellina* sp. Depressions at the top of the framestone layer are


formation
chrone (?) & zone
metres
bed No.:
interval No.:
Lišeň Formation
Macocha Formation
Pa. marginifera
Pa. crepida
Pa. triangularis ?
Upper Pa. gigas ?
0
1
2
3
4
5
6
7
8
9
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20A,B
I
II
III
IV
V
VI
VII
VIII
SELECTED FOSSILS
Palmatolepis marginifera
Septobrunsiina sp., Paratikhinella cannula, Caligella gracilis breviseptata
Palmatolepis crepida, Rauserina sp., Archaeosphaera sp.
Pa. crepida
Natalophyllum perspicuum, Scoliopora denticulata rachitiforma, Tabulophyllum maria, Habrostroma cf. incrustans, Stromatoporella sp.
Conodonta indet.
Alaiophyllum jana, Disphyllum veronica, Palmatolepis crepida, Scoliopora denticulata vassinoensis
Alaiophyllum jana, Rugosa indet.
Actinostroma sp.
Amphipora moravica, Am. tschussovensis
Labechia cumularis, Syringopora volkensis, Tienodictyon sp.
Scoliopora kaisini, Nanicella sp.
Syringostroma vesiculosum tenuilaminatum, Stromatopora sp.
Taleastroma sp.
a
b
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often filled with coquina of thin-walled smooth brachiopods (unidentified broken valves). Thickness 5–35 cm.

6: Biomicritic limestone with Moravamminidae indet. and Amphipora fragments. The sediment was homogenized by bioturbation, somewhere only partially. Thickness 22 cm.

7: Biomicritic limestones densely packed with Amphipora fragments. The stems are slim, variously abraded. Nearly a half of the volume dissolves during the compaction, the insoluble residue contains ample dolomitic crusts of a brownish colour caused by the Fe-pigment. Thickness 17 cm.

8: At the base biomicritic limestone with pyrite crystals prevails, upward sparite becomes more frequent. Stachyods, Amphipora stems dominate together with the first occurrence of *Scoliopora denticulata rachitiforma* HLADIL in the section. Thickness 27 cm.

9: Biosparrudite (rudstone) with rare, irregularly shaped *Actinostroma* sp. and *Syringostroma vesiculosum* LECOMPTE. Beside *Multiseptida* sp., there are partly dissolved radiolarians and sponge spicules. Thickness 16 cm.

10: Inhomogeneous layer with intraclasts of darker micritic limestones and plasticlasts of biosparite with well-sorted grains. The layer is breccia-like, which is supported diagenetically by a partial dissolution of carbonate in the matrix. The matrix includes calcispheres. Thickness 30 cm.

11: Laminated, namely biomicritic limestone with *Moravamminidae* indet. Biosparite laminae are sporadic. On the sutures concentrates an insoluble brown residue. Thickness 8 cm.

12: Biosparite limestone packed with finely crushed gastropods, brachiopods, and calcispheres, in places with crushed Amphipora stems. Bioclasts are often micritized. Of foraminifers, *Multiseptida* sp. and *Vicinesphaera* sp. are represented. Thickness 8–17 cm.

13: Biosparite limestone, in places with micrite-rich layers. Coenostea of *Actinostroma* sp. and *Labechia cumularis* YAVORSKI were detected, locally some brachiopod debris has accumulated. The rock has been more severely compacted than the early and tightly cemented stromatoporoid coenostea. Thickness 18 cm.

14: Biosparite limestone with biomicritic lenses. We can observe the rugose

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3. Stratigraphic column of the measured section in the Western Quarry at Mokrá
*a* – clayey micritic limestones, often nodularly structured, *b* – layers with prevailing grainstone, *c* – laminated layers, *d* – buried hardground with cracks and vugs, *e* – presence of conodonts, *f* – presence of ostracods (thin but sculptured valves and closed thick-walled smooth shells), *g* – cephalopods (straight and involuted shells), *h* – crinoid ossicles, *i* – sponge spicules, *j* – partly dissolved radiolarian skeletons, *k* – foraminifers *Multiseptida* sp., *l* – foraminifers *Tournayellidae* indet., *m* – algae *Moravamminidae* indet., *n* – brachiopods and gastropods, *o* – branched and massive coenostea of stromatoporoids, *p* – Rugosa, *q* – breccia layers, *r* – tabulate sheets, *s* – branches of tabulate corals

coral *Alaiophyllum jana* GALLE, fragments of *Rugosa* indet., *Amphipora* div. sp., calcispheres, and in part dissolved radiolarians. Thickness 20 cm.

15: Thinly horizontally bedded biomicrite and fossiliferous micritic limestones with *Moravamminidae* indet., occasionally with primitive foraminifers hardly distinguishable from the matrix due to a considerable micritization. Thickness 21 cm.

16: Inhomogeneous, mostly biomicritic layers with accumulated Amphipora and brachiopods. The insoluble residue comprises sponge spicules and conodonts. Either the spicules or the conodonts always predominate. Crinoid ossicles can be noticed. Thickness 29 cm.

17: Biosparite limestone with varied coral and stromatoporoid fauna. Branches of *Natalophyllum perspicuum* HLADIL encrusted with stromatoporoids are prominent. Of foraminifers, *Mustiseptida* sp. and *Tournayellidae* indet. are more frequent. Zonal alterations of carbonate near the upper surface of the layer evidence the former exposure of the surface as hardground. Thickness 27 cm.

18: Biomicritic limestone with spread bioclasts. At the base there are laminae of biosparite with micritized or coated grains. *Amphipora moravica* ZUKALOVÁ and *Am. tschussovensis* YAVORSKI dominate in the upper part of the layer. Notable is the find of unidentified conodont fragments and cross-sections of oogonia of charophytes *Umbellina* sp. Thickness 42 cm.

19: Biosparite limestone with lenses and plasticlasts of micritic limestone. The foraminifers *Multiseptida* sp. and *Tournayellidae* indet. are present. The coral *Scoliopora denticulata vassinoensis* DUBATOLOV is ubiquitous here and observable throughout the layers 16—20. With the locally increased amount of micrite rises the occurrence of *Archaesphaera* sp. and *Cribrosphaeroides* sp. Thickness 40 cm.

20A: Biosparite limestone with frequent, ball-shaped and encrusting coenostea of *Habrostroma* cf. *incrustans* (HALL et WHITFIELD), *Actinostroma* sp., and *Stromatoporella* sp. and other species — comp. tab. 1. Most of the coenostea are in situ and the overturned ones are often coated with algae. Broken stachyods bear signs of local transport. The insoluble residue contains a larger amount of pyrite framboids; sulphides and organic matter are often free from oxidization. This part of the layer is 38 cm thick.

20B: Fine-grained biosparite with admixtured micrite and clay. Conodonts and a phosphatic crushed mass of more robust unidentified skeletons (plates of Placodermi?) are widespread. There were found tiny crinoid ossicles. Fine debris of altered Amphipora tissues appears already as part of intraclasts together with the original surrounding cement or sediment. This part of the layer is 3—5 cm thick.

If the above microfacies are considered from the viewpoint of WILSON's (1975) classification of standard microfacies, changing of the two associations may be stated: microfacies with ubiquitous micrite and reef-building or accompanying organisms (SMF 7, 8, 9) on the one hand, and well-washed coarse-grained sediments (SMF 11, 12, 18) on the other. The environment is interpreted as a shallow

Table 1

Fossils in beds of int. I–VIII, Western Quarry, Mokrá section, in a wider time span near the Frasnian/Famennian boundary

Křtiny Limestones Vilémovice Ls. (Mokrá Ls./4th megacycle) member

| interval | VIII | VII | VI | V | IV | | III | | | | II | | | | | | | | | I | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bed | | | | | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | -1 | -2 | -3 |
| TABULATA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scoliopora denticulata vassinoensis | | | | | ● | ● | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| S. denticulata rachitiforma | | | | | ● | | | ● | ● | | | | | | | | ● | | | | | | | | | | | |
| S. kaisini | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | |
| Natalophyllum perspicuum | | | | | ● | ● | | ● | ● | | | | | | | | | | | | | | | | | | | |
| Syringopora volkensis | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | |
| Aulostegites sp. | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | |
| RUGOSA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alaiophyllum jana | | | | | | | ● | ● | ● | | ● | | | | | | | | | | | | | | | | | |
| Disphyllum veronika | | | | | | | | ● | ● | | | | | | | | | | | | | | | | | | | |
| Tabulophyllum maria | | | | | ● | | | ● | | | | | | | | | | | | | | | | | | | | |
| Rugosa indet. | | | | | | | | ● | | | ● | | | | | | | | | | | ● | | | | | | |
| STROMATOPOROIDEA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Amphipora moravica | | | | | ● | ● | ● | | ● | | ● | ● | ● | | | | ● | ● | ● | | ● | ● | ● | ● | | ● | | |
| A. tschussovensis | | | | | ● | ● | ● | | ● | | ● | ● | | | | | ● | | | | | | | | | | | |
| A. hanimedi | | | | | | | | | | | | | | | | | | | | | ● | | ● | | | ● | | |
| Habrostroma cf. incrustans | | | | | ● | | | ● | | | | | | | | | | | | | | | | | | | | |
| Stromatopora sp. | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | |
| Stromatoporella sp. | | | | | ● | | | | | | | | | | | | | | | | | | | | | | | |
| Atelodictyon ? sp. | | | | | ● | | | | | | | | | | | | | | | | | | | | | | | |
| Tienodictyon sp. | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | |
| Labechia cumularis | | | | | | | | | | | | ● | | | | | | | | ● | | | | | | | | |
| Taleastroma sp. | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | |
| Stachyodes sp. | | | | | ● | | | ● | | | | | | | | | ● | ● | | | | | | | | | | |
| S. cf. lagowiensis | | | | | | | | | | | | | | | | | | | | | ● | ● | | | | | | |
| Actinostroma sp. | | | | | ● | | | | | | | ● | | | | ● | | | | | | ● | | | | | | |
| Syringostroma vesiculosum | | | | | | | | | | | | | | | | ● | | | | | | ● | | | | | | |
| S. vesiculosum tenuilaminatum | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | |
| FORAMINIFERA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Archaesphaera sp. | | | ● | ● | ● | ● | ● | | | | | | | | | | | | | | | | | | | | | |
| Auroria ferganensis | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baituganella sp. | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bisphaera sp. | | ● | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | |
| Caligella gracilis breviseptata | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Caligella sp. | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cribrosphaeroides sp. | | ● | | | | ● | ● | | ● | | | | | | | | | | | | | | | | | | | |
| Geinitzinidae indet. | | | | | | ● | | | ● | | | | | | | | | | | | | | | | | | | |
| Irregularina sp. | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | |
| Multiseptida sp. | | | | | ● | ● | | ● | | | | | ● | ● | | ? | | | | | | ● | | | ● | | | |
| Parathurammina sp. | | ● | | | ● | ● | | ● | | | | | | | | | | | | | | | | | | | | |
| Paratikhinella cannula | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Paratikhinella sp. | | ● | | | | ● | | | ● | | | | | | | | | | | | | | | | | | | |
| Rauserina sp. | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | |
| Septabrunsiina sp. | ● | ● | | ● | | | | | | | | | | | | | | | | | | | | | | | | |
| Sphaerella sp. | | ● | | | | | ● | | ● | | | | | | | | | | | | | | | | | | | |
| Tikhinella cf. fringa | | ● | | | | | | | ● | | | | | | | | | | | | | ● | | | | | | |
| T. cf. measpis | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tournayellidae indet. | | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | | | | | | |
| Vicinesphaera sp. | | ● | | | ● | ● | ● | | ● | | | | ● | ● | | | | | | ● | ● | | | | | | | |
| Nanicella sp. | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | | | |
| ALGAE | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Calcisphaera sp. | | | | | ● | ● | ● | ● | ● | | ● | | | | ● | | ● | | | ● | ● | | | | | | | |
| Issinella sp. | | | | | | | | | | | | | | | | | | | | ● | | | | | ● | ● | | |
| Moravamminidae indet. | | | | ● | | | | | | ● | | | | ● | | | | | ● | ● | | | | | ● | | | |
| Palaeoplysina sp. | | | | | | | ● | | | | | | | | | | | | | | | | | | | | | |
| Solenoporaceae indet. | | | | | ● | ● | | ● | | | | | | | | | | | | | | ● | | | | | | |
| Umbellina sp. | | | | | | | ● | | | | | | | | | | | | | ● | | | | | | | | |

ramp, more or less exposed to the basin, although extensive micritization and in the lower part of the section even episodic levels with subaeral carbonate diagenesis are observed. Significant is the occurrence of conodonts, sponges, radiolarians, and oogonia of charophytes, especially in the upper part of the section (comp. fig. 3, tabs. 1, 2). The conodonts and radiolarians point to the connection with the basinal sedimentary space, the oogonia rather to a connection with near-shore freshened spaces.

## Comparison of the Mokrá section with boreholes HV-105 Křtiny and V-204 Lesní lom

In the borehole HV-105 Křtiny (Dvořák et al. 1984) O. Friáková confirmed the conodont Palmatolepis crepida Zone from the depth of 145.1 to 152.3 m. Biosparite, biopelsparite, and biointrasparrudite limestones in the lower part of this depth range have a reefal character and are bound with plates of stachyods and algae (stachyods in coating adaptation). The formerly problematic coral (depth 152.3 m) could be identified now according to the Mokrá fauna as *Natalophyllum perspicuum* Hladil. At the depth of 149.8 m *Stachyodes* sp. were detected (thin-section collection of V. Skoček). Dvořák et al. (1984) give the following thicknesses of carbonate deposits of the individual conodont zones (downward): Palmatolepis crepida — 8 m, Palmatolepis triangularis — 10 m, Palmatolepis gigas — 12 m. The limestones have developed in the reef cap facies along a more steeply modelled frontal margin of buildups and, therefore, higher thicknesses than on the flat ramp or shoal margin of the Mokrá buildups may be expected.

Similarly, in the borehole V-204 Lesní lom O. Friáková evidenced the conodont fauna of the Palmatolepis crepida Zone coming from the depth of 75.1 m. Thin-sections of the rock derived from depths around 73.5 m (E. Možíšová's collection) point to the presence of biointrasparrudite limestones with coated and micritized grains, algal laminae, with redeposited, diagenetically cemented nodules, crushed brachiopods, and stromatoporoid coenostea. The uppermost, micrite-rich part of the sequence contains cephalopod shells. The upper limit lying at a 73.1 m depth seems analogous to the base of interval V of the Mokrá section. In rocks similar to those encountered in the borehole V-204 at depths about 73.5 m *Natalophyllum perspicuum* Hladil was discovered in the exposure at Lesní lom. The rocks, therefore, may be considered analogous to those of int. IV in the measured section at Mokrá.

Contrary to that, in the time-equivalent sequence of the Jedovnice section (evaluation carried out by Z. Krejčí and J. Dvořák) occur fossiliferous micrites with admixed clay, very finely dispersed detritus, conodonts, thin-walled but markedly sculptured ostracods, and partly dissolved radiolarians. At the base of the interval referring to the Palmatolepis crepida Zone stromatolithic structures appear. The limestones are mostly nodular and there do not occur any fragments of reef-building organisms, if only redeposited.

## Location of the Frasnian/Famennian boundary in the Mokrá section

The Mokrá section did not provide any conodont assemblages earlier than those of the Palmatolepis crepida Zone. Accordingly, namely the tabulates, rugose corals, and stromatoporoids were employed for zoning. The zoning resulted from correlation with the conodont fauna in the borehole HV-105 Křtiny, in the south-eastern slopes of the Bohemian Massif under the Carpathian nappes, as well as in the exposures of Hády Hill and the hillock near Bedřichovice (comp. GALLE 1985, HLADIL 1983). Also the indications of the foraminiferal fauna and ecostratigraphic phenomena were taken into consideration.

In the upper part of int. I of the Mokrá section there were ascertained the last occurrences of *Scoliopora kaisini* (LECOMPTE), *Syringostroma vesiculosum tenuilaminatum* ZUKALOVÁ, *Clathrocoilona brunnensis* ZUKALOVÁ, and in fragments also the foraminifers *Nanicella* sp. According to correlations known in Moravia, the occurrences are significant of the uppermost Frasnian (comp. ZUKALOVÁ 1971, 1981). The fauna is typical of the Zones Frechastraea pentagona or Crassialveolites domrachevi, although index species as reefal, stenofacies taxa have neither been found at Mokrá (comp. HLADIL 1983). At the locality Šumbera at Hády near Brno, Rozcestí Křtiny, and in the borehole Jablůnka-1 in northern Moravia, 6 km NNW of Vsetín, the levels were correlated with the conodont Palmatolepis gigas Zone (HLADIL 1983, 1986, ZUKALOVÁ - FRIÁKOVÁ 1987).

Above the interval I there is a prominent gap. For a longer period the deposits of the interval had a hardground surface which also emerged (fills of vadose silt). It is covered with complicatedly concreting coral and stromatoporoid sheets (up to 400 × 35 cm in size) of *Labechia cumularis* YAVORSKI, *Syringopora volkensis* TCHERNYSCHEV (both considered Famennian — Vaigach Island in the n. continuation of the Ural Mountains), and other species.

Changes in function morphology (in the case of stromatoporoids a preference of vesiculose and laminar tissues, suppression of vertical elements, in the case of tabulates suppression of massive coralla) have a general character of the transition into the Famennian. However, the age of holotypes of both the above-mentioned species cannot be specified, for the identification of the samples' origin is uncertain (comp. YAVORSKI 1957). Some species at the base of int. II exhibit features common with the upper Frasnian faunas (*Tienodictyon* sp., *Syringostroma vesiculosum* LECOMPTE), but their skeletons are lighter and the vertical elements slightly reduced. *Nanicella* sp. does not occur here any more. Int. II is supposingly of the same age as the conodont Palmatolepis triangularis Zone or even the boundary of the Pa. triangularis and Pa. crepida. It was inferred from the "upward" and "downward" faunal limitation and a similarity to lithological and ecological sequences in other sections of the Moravian Karst where the conodonts do occur (boreholes V-204 and HV-105).

The layers of the interval III already contain both the conodonts and the corals (*Disphyllum veronika* GALLE) typical of the Palmatolepis crepida Zone.

In the section the Fransian/Famennian boundary is hypothetically placed into the gap between intervals I and II. The fauna below the gap corresponds to the upper part of the Palmatolepis gigas Zone, moreover, the indications of a longer gap between the both intervals also speak in favour of such a location. However, we cannot fully exclude a less probable position of the boundary in the lower part of int. II. The boundary itself is considered in the sense of the Lower/Middle Palmatolepis triangularis Zone. The facies is being correlated with transgressive-regressive eustatic pulsations (tab. 3). The transgressive pulsation in the uppermost part of the Palmatolepis gigas Zone is generally known (comp. WALLISER 1985) and the linked up regressive pulsation should be well recorded in reef shoals - the gap between the intervals I and II is being associated with this regressive pulsation (comp. tab. 3).

## Discussion on manifestations of the Kellwasser Event

Evolution crises of the reef-building communities in Moravia occur with a higher frequency from mid-levels of the Frasnian (comp. DVOŘÁK - FRIÁKOVÁ 1978, Hranice environs), nevertheless, the most notable crises are associated with the Kellwasser series of events (HLADIL et al. 1986). They are linked up with a decrease in the diversity of coral and stromatoporoid communities (according to Shannon-Weaver's index the value lowers from about 2.5 to roughly 0.5). Massive and intensively skeletonized colonies are considerably reduced and gradually displaced by branched and slightly skeletonized colonies. The population number strikingly lowers.

According to the present ideas (Conference on Global Bioevents in Göttingen 1986; WALLISER 1986, WILDE-BERRY 1986, HLADIL et al. 1986), three significant levels of black basin horizons (the uppermost part of the lower part of the Palmatolepis gigas Zone, the uppermost part of the Palmatolepis gigas Zone, and mid-levels of the conodont Palmatolepis triangularis Zone) indicate pulsation maxima of the uplift of anoxic waters together with the general eustatic uplift of the sea level. The uplift maxima are reflected also in carbonate platforms which display comparatively thick reef banks (not dark-coloured sediments as it is in the case of lower-situated bottoms in adjoining areas).

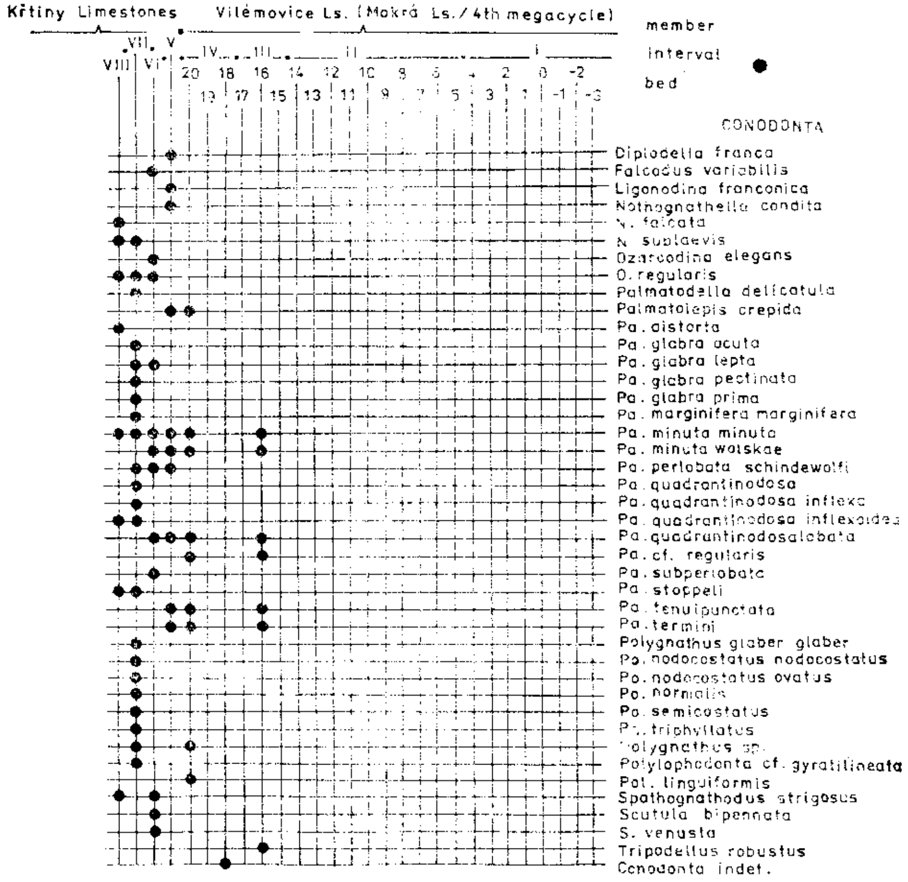
In the basin the eustatic minima between the three levels meant the return of oxidized waters down to the bottom, while on the carbonate platforms could form partly closed shallow lagoons with interrupted fillings of black lagoonal sediments. Thus, on condition that this idea is right, black horizons in the basin sequences on the one hand alternated with black shallow-water horizons on the other.

Of the section measured rather the upper parts of int. I may be correlated with the transgressive event from the uppermost part of the conodont Palmatolepis gigas Zone. The transgressive event in the mid-level of the Palmatolepis triangularis Zone is most probably connected with the deposition of beds 8—10 in the interval II.

Surprising is the survival of the reef-building fauna of the measured section even after the Kellwasser Event, although less diversified and with changes in preferred function morphology. Total extinction of the Mokrá section reef-building fauna falls into the upper part of the conodont Palmatolepis crepida Zone. The reason of this locally ascertained extinction most probably consists in changes in the flow configuration and sea water chemistry. The upper part of the conodont Palmato-

Table 2

Conodont fauna in beds and intervals of the measured section



Under the bed No. 16 and the Palmatolepis crepida Zone no conodonts have been ascertained lepis crepida Zone is devoid of any more apparent break in the biostratigraphical record resulting from the emergence during the regression, for Euramerica supposed on this time level (JOHNSON et al. 1985). However, the problem can be regarded also in a hitherto insufficient biostratigraphical correlation – in the upper part of the Palmatolepis crepida Zone more T-R pulses may be masked.

The reef-building fauna was influenced not only by more pronounced eustatic pulses or pulses in the movement of anoxic waters, but also by other significant factors, such as the restriction of shelves from tectonic reasons (DVOŘÁK et al. 1986) and the increased humidity of the climate (KALVODA 1986, HLADIL et al. 1986).

The increasing humidity is obvious from the rising number of continental outwashes into the sedimentary sequences, from a higher occurrence of charophytes' oogonia, and other indications. The eustatic pulsations thus probably evoked crises of the reef-building assemblages which had already been under a stress from palaeogeographical and climatic reasons. Furthermore, we cannot exclude ecological crises the reasons of which can hardly be deciphered due to a fossil state, and that need not be immediately linked up with physico-chemical parameters of the environment. ●

## Notes on the individual faunal groups of the Mokrá section

The individual groups of fauna were described by FRIÁKOVÁ et al. 1985. Especially the study of the stromatoporoids was completed (the total species spectrum, however, is even wider).

Within the interval I typically occur *Amphipora moravica* ZUKALOVÁ together with *Am. hanimedi* YAVORSKI, furthermore *Syringostroma vesiculosum tenuilaminatum* ZUKALOVÁ, *Taleastroma* sp., *Stachyodes* cf. *lagowiensis* GOGOLCZYK, *Actinostroma* sp., *Stromatopora* sp.; *Clathrocoilona brunensis* ZUKALOVÁ is supposed.

Interval II comprises the following stromatoporoids: *Tienodictyon* sp., *Labechia cumularis* YAVORSKI, *Syringostroma vesiculosum* LECOMPTE, *Actinostroma* sp., and *Amphipora moravica* ZUKALOVÁ together with *Amphipora tschussovensis* YAVORSKI.

Intervals III and IV contain stromatoporoids *Habrostroma* cf. *incrustans* (HALL et WHITFIELD), *Labechia cumularis* YAVORSKI, *Actinostroma* sp., *Stachyodes* sp., *Atelodictyon*? sp., and *Stromatoporella* sp.

Near the supposed Frasnian/Famennian boundary between the intervals I and II there was a shift favouring the labechiids and stromatoporoids with lighter skeletons, but the process was gradual, starting as early as in the Upper Frasnian (ZUKALOVÁ 1971; V. Zukalová – personal communication, 1986). As regards the measured section at Mokrá, it should be added that the process went on after the Frasnian/Famennian boundary period.

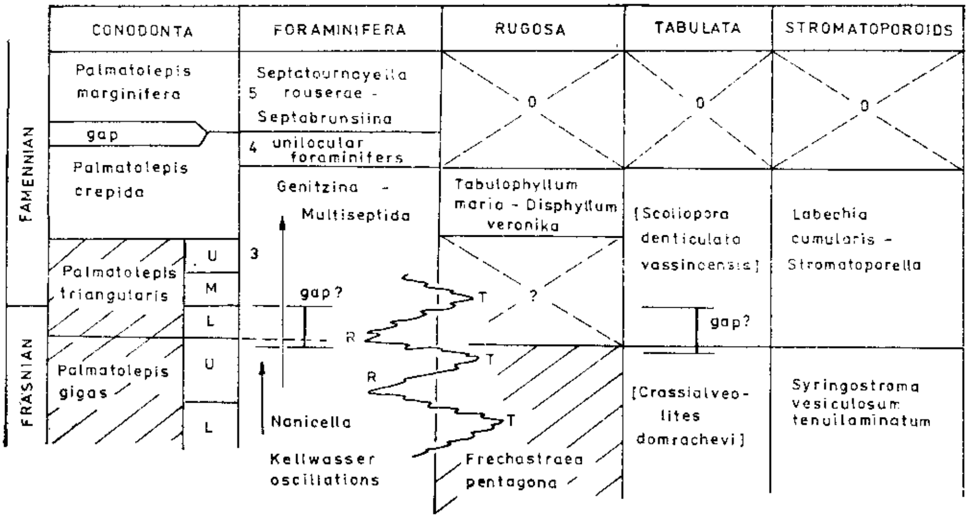
From the viewpoint of the rugose corals, intervals III and IV are best characterized by the presence of *Tabulophyllum maria* Galle and *Disphyllum veronika* Galle. *Alaiophyllum jana* Galle occurs in int. II and prospectively also in int. I, for A. Galle revealed conspecific occurrences also at the locality Šumbera, in layers levelling the conodont Palmatolepis gigas Zone.

In the case of the tabulate corals the situation is similar: *Natalophyllum perspicuum* has been ascertained only in the deposits of the Palmatolepis crepida Zone (Western Quarry at Mokrá, borehole Křtiny HV-105, Lesní lom), whereas *Scoliopora denticulata rachitiforma* Hladil appears in the upper Frasnian (borehole HV-105 Křtiny; depth 166.5 m; Palmatolepis gigas Zone) and penetrates into the Palmatolepis triangularis Zone (V-204, Lesní lom, the measured section at Mokrá) and even to the Pa. crepida Zone (only at Mokrá for the present). Significant is the occurrence of the coral *Scoliopora denticulata vassinoensis* Dubatolov, which is frequent at the Frasnian/Famennian boundary especially after the extinction of *Crassialveolites* div. sp. (exposures at Klajdovka near Brno). In the Mokrá section this subspecies has been detected so far in intervals III and IV, not in int. II.

In the foraminiferal zoning the intervals I – IV of the Mokrá section were unified into the zone No. 3 = Geinitzina – Multiseptida. Analogically to the Křtiny valley section, where *Nanicella* sp. has not been reported higher than the conodonts of the Palmatolepis gigas Zone (Vokounka and Žitný's cave), the last occurrence of

Table 3

Correlation of parastratigraphies according to conodonts, foraminifers, groups Tabulata, Rugosa, and Stromatoporoidea with respect to the Mokrá section, Western Quarry



| | CONODONTA | | FORAMINIFERA | RUGOSA | TABULATA | STROMATOPOROIDS |
|---|---|---|---|---|---|---|
| FAMENNIAN | Palmatolepis marginifera | | 5 Septatournayella rouserae - Septabrunsiina | 0 | 0 | 0 |
| | gap | | 4 unilocular foraminifers | | | |
| | Palmatolepis crepida | | 3 Genitzina - Multiseptida | Tabulophyllum maria - Disphyllum veronika | [Scoliopora denticulata vassinoensis] | Labechia cumularis - Stromatoporella |
| | Palmatolepis triangularis | U | | ? | | |
| | | M | gap? | T | | |
| FRASNIAN | | L | R | | gap? | |
| | Palmatolepis gigas | U | R T | | [Crassialveolites domrachevi] | Syringostroma vesiculosum tenuilaminatum |
| | | L | Nanicella | T Frechastraea pentagona | | |

Zones in the section hitherto unestablished are given in inclined shading; not described so far intervals, neither at Mokrá, nor in whole Moravia are given in dashed line. The curve indicates supposed eustatic fluctuations in the time of the Kellwasser Event (or a series of events)

*Nanicella* sp. in the Mokrá section is being assigned to the upper limit of the Palmatolepis gigas Zone.

## Conclusions

1. The upper limit of the Macocha Formation (ZUKALOVÁ - CHLUPÁČ 1982, for more details see HLADIL in CHLUPÁČ et al. 1986) in the Mokrá section is dated to the upper part of the conodont Palmatolepis crepida Zone. Geologically it represents buildups covered with post-reef carbonate sediments (breccia, clayey micritic limestones with nodular structures, detrital banks alternating with claystones).
2. In the section there were described coral and stromatoporoid assemblages of the Palmatolepis crepida Zone occurring in association with conodonts (comp. tabs. 1, 2), therefore namely the species *Amphipora tschussovensis* YAVORSKI, *Labechia cumularis* YAVORSKI, *Natalophyllum perspicuum* HLADIL, *Tabulophyllum maria* GALLE, and *Disphyllum veronika* GALLE may be employed in the correlation of the Lower Famennian in sections lacking preserved conodonts, e.g., in the area "South" on the se. slopes of the Bohemian Massif, under the Carpathian nappes.
3. The Frasnian/Famennian boundary is indicated by the last occurrence of *Scoliopora kaisini* (LECOMPTE) — Tabulata, *Nanicella* sp. — Foraminifera, *Syringostroma vesiculosum tenuilaminatum* ZUKALOVÁ — Stromatoporoidea, moreover, by the decrease in the diversity of reef-building assemblages, and a higher frequency of species with incompact and lighter skeletons. The conodonts are absent at the Frasnian/Famennian boundary at Mokrá, but they were detected in other sections suitable for correlation (HV-105, Křtiny Rozcestí, or V-204 Lesní lom).

*K tisku doporučil I. Chlupáč*
*Přeložila G. Buberlová*

Remark: The Subcommission on Devonian Stratigraphy (Calgary, August 22, 1987) established the Frasnian/Famennian boundary at the base of the conodont Palmatolepis triangularis Zone. This implies a more precise interpretation of the Mokrá section boundary — between the intervals I and II.

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## Explanation of plates

### Pl. I

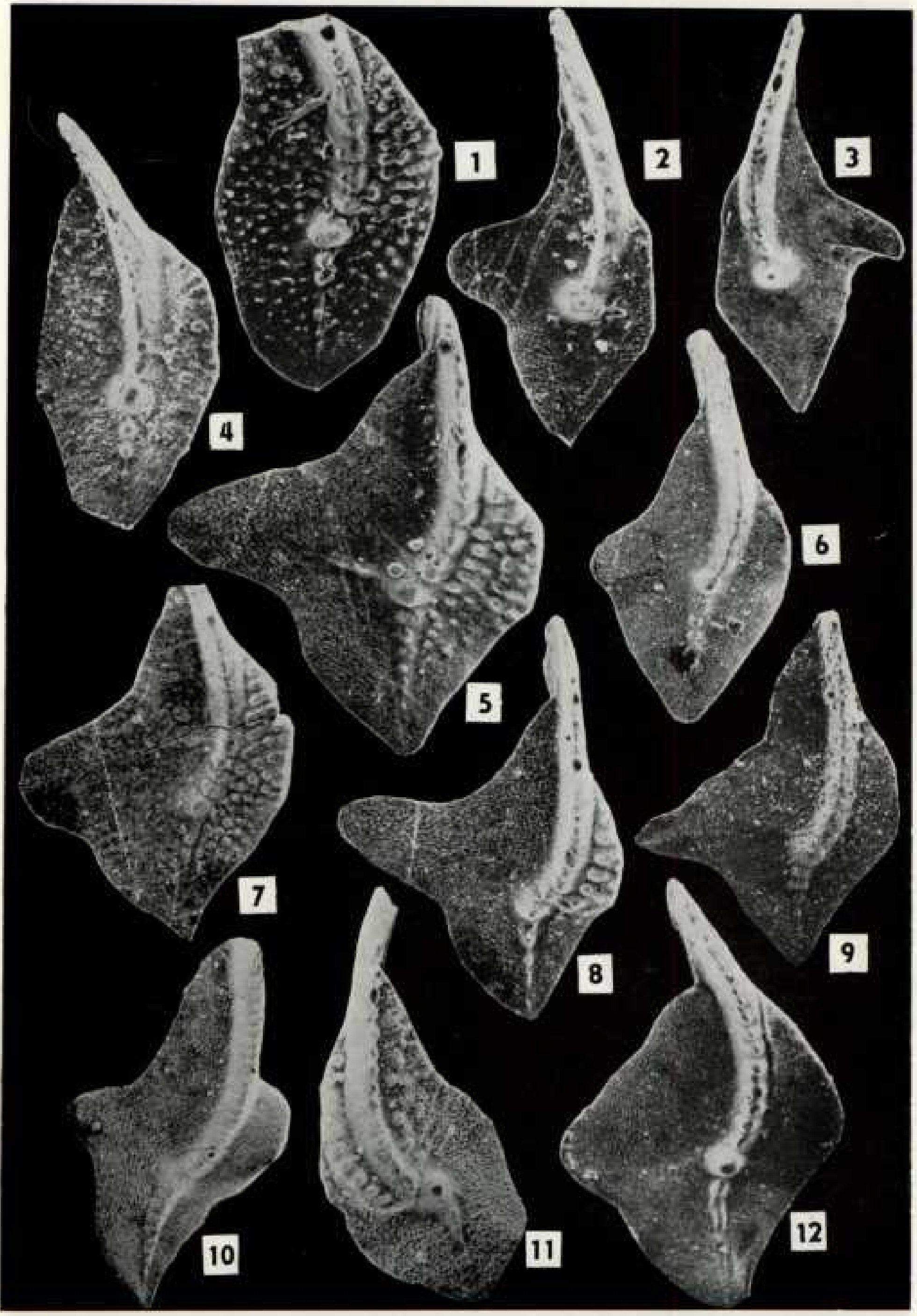
1. *Palmatolepis crepida* SANNEMANN, bed 20, Palmatolepis crepida Zone, × 60.
2. *Palmatolepis minuta wolskae* SZULCZEWSKI, bed 16, Palmatolepis crepida Zone, × 65.
3. *Palmatolepis minuta wolskae* SZULCZEWSKI, bed 16, Palmatolepis crepida Zone, × 60.
4. *Palmatolepis crepida* SANNEMANN, bed 20, Palmatolepis crepida Zone, × 65.
5. *Palmatolepis quadrantinodosalobata* SANNEMANN, interval V, Palmatolepis crepida Zone, × 60.
6. *Palmatolepis minuta minuta* BRANSON et MEHL, bed 16, Palmatolepis crepida Zone, × 65.
7. *Palmatolepis quadrantinodosalobata* SANNEMANN, bed 20, Palmatolepis crepida Zone, × 65.
8. *Palmatolepis quadrantinodosalobata* SANNEMANN, bed 20, Palmatolepis crepida Zone, × 60.
9. *Palmatolepis subperlobata* BRANSON et MEHL, interval VI, Palmatolepis crepida Zone, × 65.
10. *Palmatolepis tenipunctata* SANNEMANN, bed 20, Palmatolepis crepida Zone, × 60.
11. *Palmatolepis termini* SANNEMANN, interval V, Palmatolepis crepida Zone, × 65.
12. *Palmatolepis* cf. *regularis* COOPER, bed 20, Palmatolepis crepida Zone, × 65.

### Pl. II

1. *Palmatolepis tenuipunctata* SANNEMANN, interval V, Palmatolepis crepida Zone, × 85.
2. *Palmatolepis glabra lepta* ZIEGLER et HUDDLE, interval VI, Palmatolepis crepida Zone, × 70.
3. *Palmatolepis glabra lepta* ZIEGLER et HUDDLE, interval VI, Palmatolepis crepida Zone, × 70.
4. *Palmatolepis glabra pectinata* ZIEGLER, interval VII, Palmatolepis marginifera Zone, × 70.
5. *Palmatolepis termini* SANNEMANN, bed 16, Palmatolepis crepida Zone, × 80.
6. *Palmatolepis glabra prima* ZIEGLER et HUDDLE, interval VII, Palmatolepis marginifera Zone, × 80.
7. *Palmatolepis glabra distorta* BRANSON et MEHL, interval VIII, Palmatolepis marginifera Zone, × 65.
8. *Palmatolepis quadrantinodosa* cf. *inflexoidea* ZIEGLER, interval VII, Palmatolepis marginifera Zone, × 60.
9. *Palmatolepis glabra pectinata* ZIEGLER, interval VII, Palmatolepis marginifera Zone, × 60.
10. *Palmatolepis quadrantinodosa inflexa* MÜLLER, interval VII, Palmatolepis marginifera Zone, × 85.
11. *Palmatolepis stoppeli* SANDBERG, interval VII, Palmatolepis marginifera Zone, × 60.
12. *Palmatolepis stoppeli* SANDBERG, interval VIII, Palmatolepis marginifera Zone, × 60.

### Pl. III

1. *Polygnathus normalis* MILLER et YOUNGQUIST, interval VII, Palmatolepis marginifera Zone, × 50.
2. *Polygnathus normalis* MILLER et YOUNGQUIST, interval VII, Palmatolepis marginifera Zone, × 50.
3. *Polygnathus semicostatus* BRANSON et MEHL, interval VII, Palmatolepis marginifera Zone, × 50.
4. *Polygnathus semicostatus* BRANSON et MEHL, interval VII, Palmatolepis marginifera Zone, × 50.
5. *Palmatolepis perlobata schindewolfi* MÜLLER, interval V, Palmatolepis crepida Zone, × 70.
6. *Palmatolepis marginifera marginifera* HELMS, interval VII, Palmatolepis marginifera Zone, × 60.
7. *Palmatolepis marginifera marginifera* HELMS, interval VII, Palmatolepis marginifera Zone, × 60.
8. *Palmatolepis quadrantinodosa* BRANSON et MEHL, interval VII, Palmatolepis marginifera Zone, × 65.
9. *Polygnathus triphyllatus* (ZIEGLER), interval VII, Palmatolepis marginifera Zone, × 42.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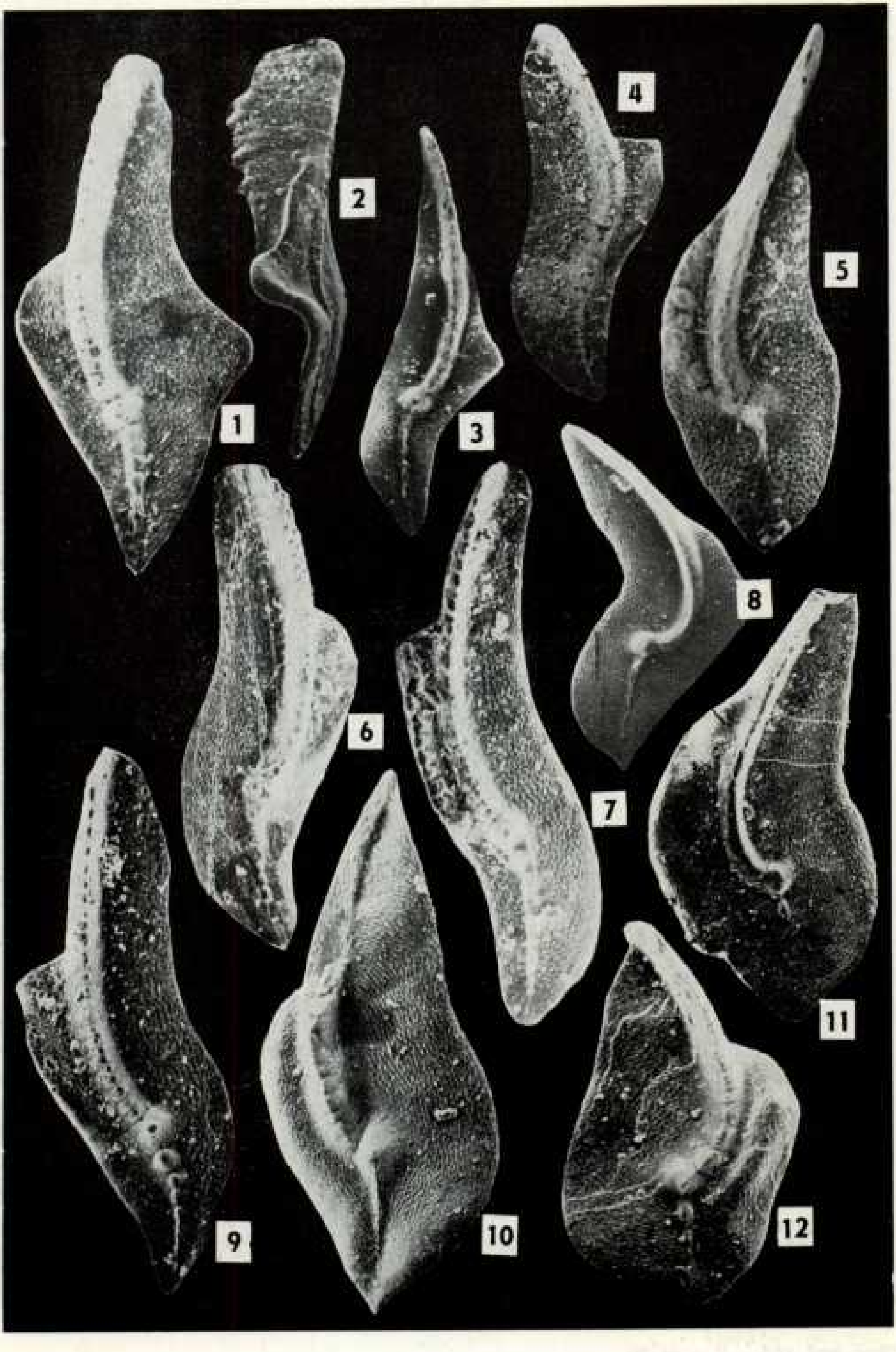
Pl. II



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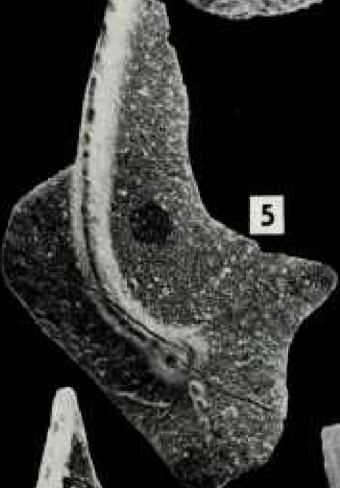

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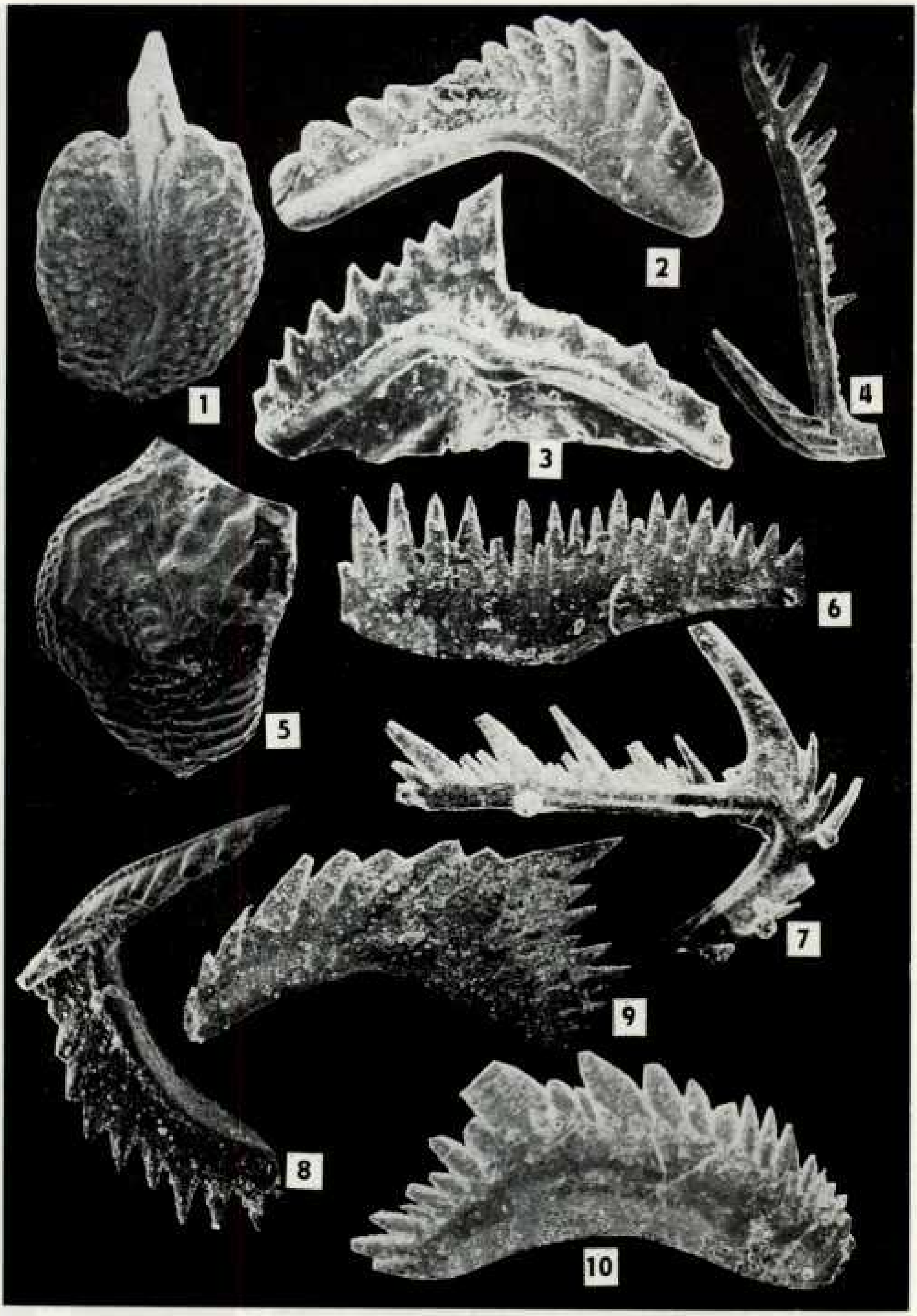
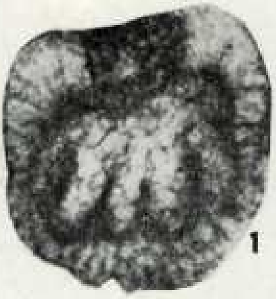
Pl. IV



J. Hladil - J. Kalvoda - O. Friáková - A. Galle - Z. Krejčí: Pl. V
Fauna from the limestones at the Frasnian/Famennian boundary at Mokrá
(Devonian, Moravia, Czechoslovakia)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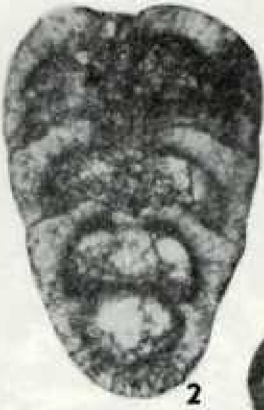
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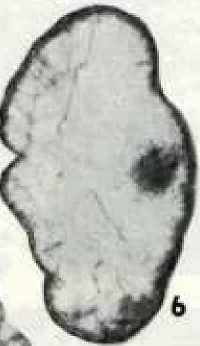
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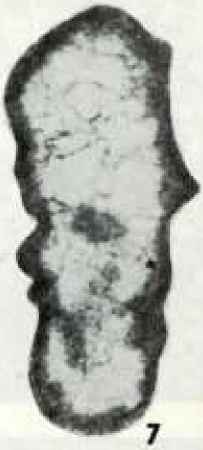
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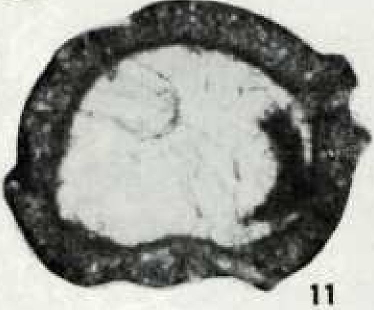
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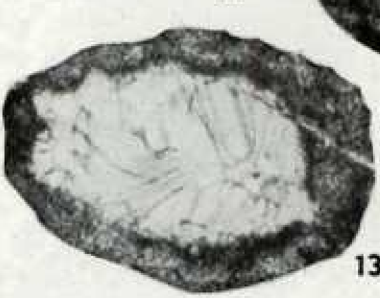
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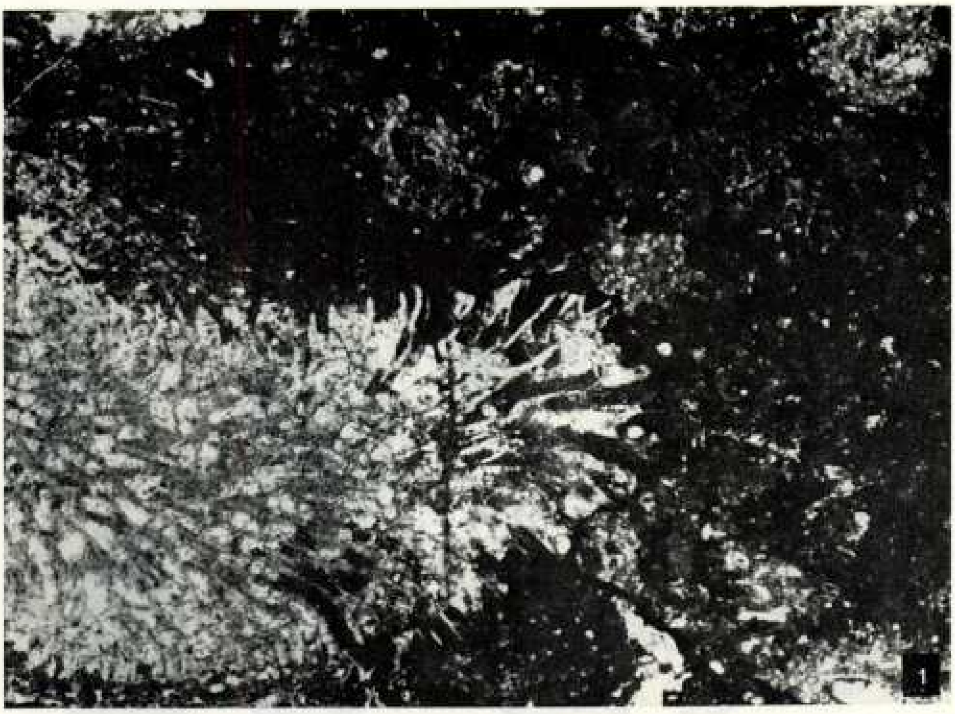
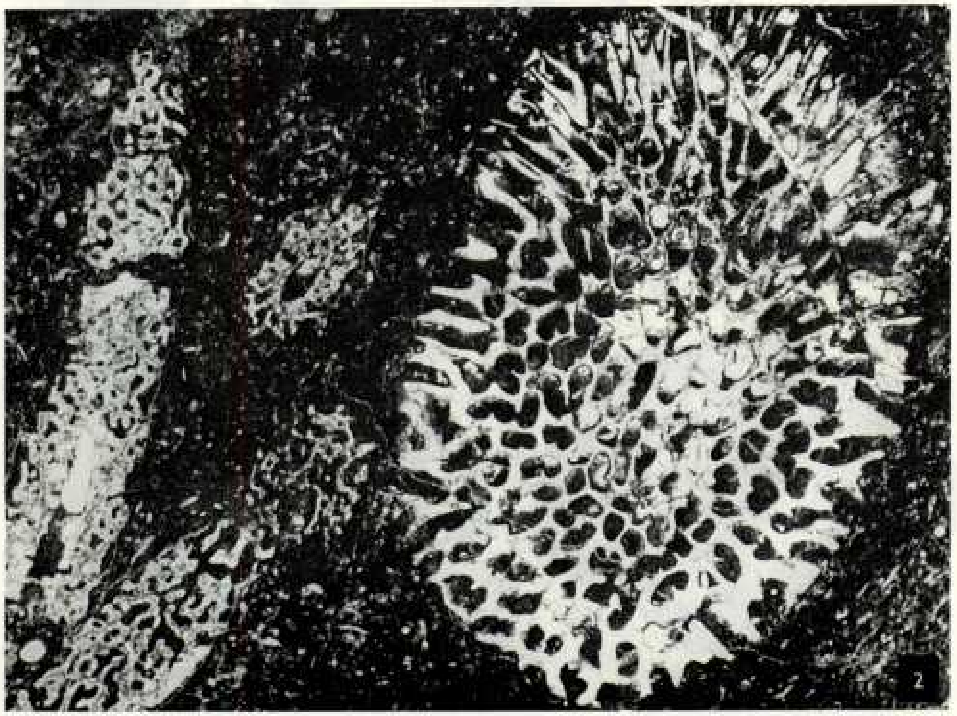
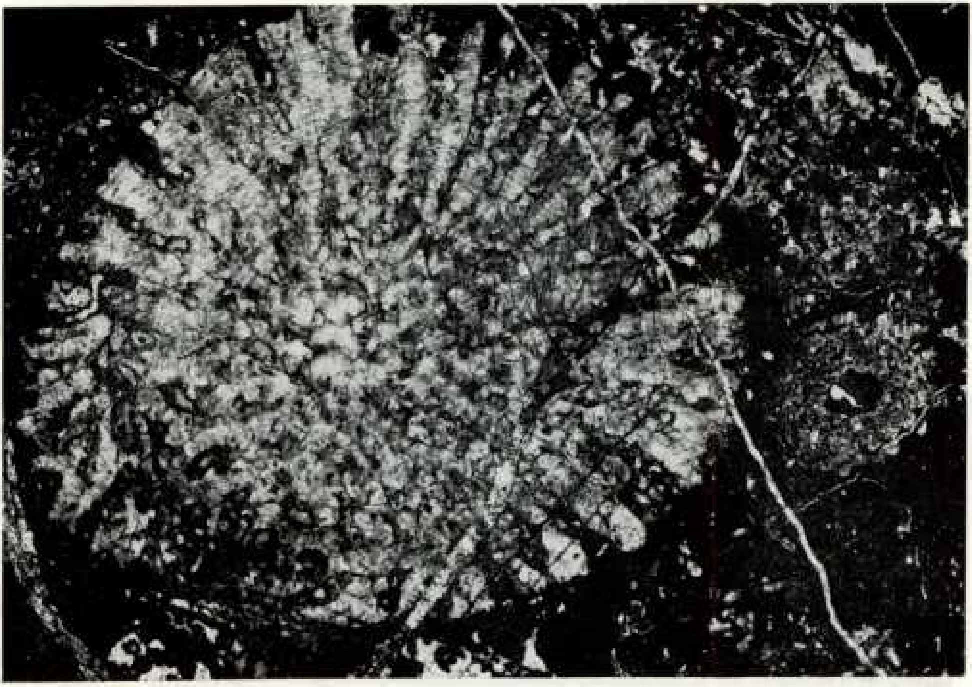
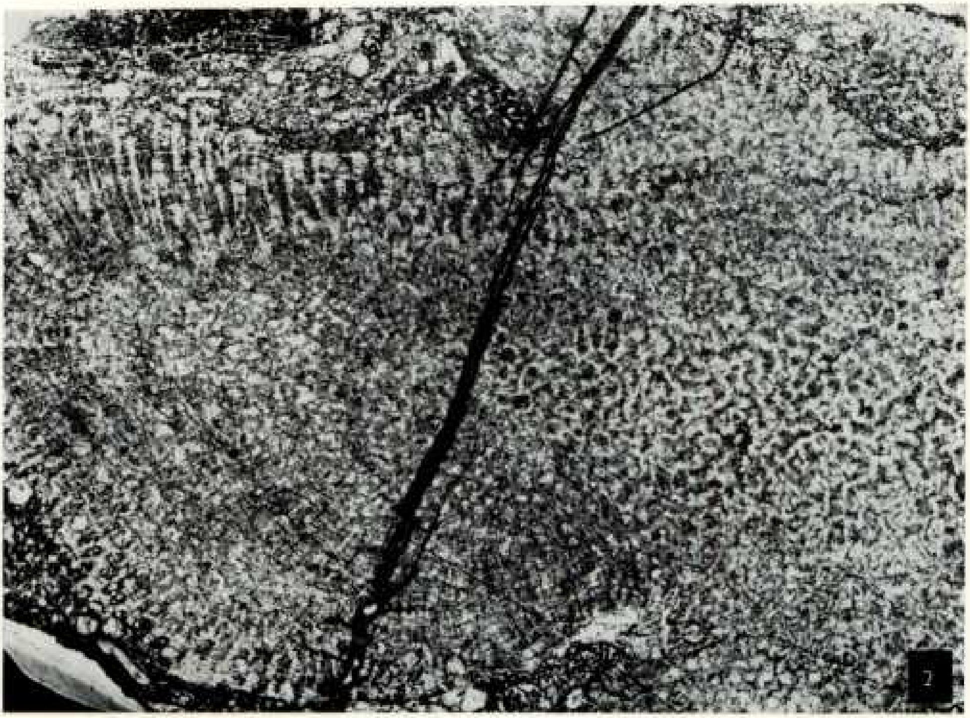
Pl. VI





J. HLADIL - J. KALVODA - O. FRIÁKOVÁ - A. GALLE - Z. KREJČÍ: Pl. VII
Fauna from the limestones at the Frasnian/Famennian boundary at Mokrá
(Devonian, Moravia, Czechoslovakia)





Pl. VIII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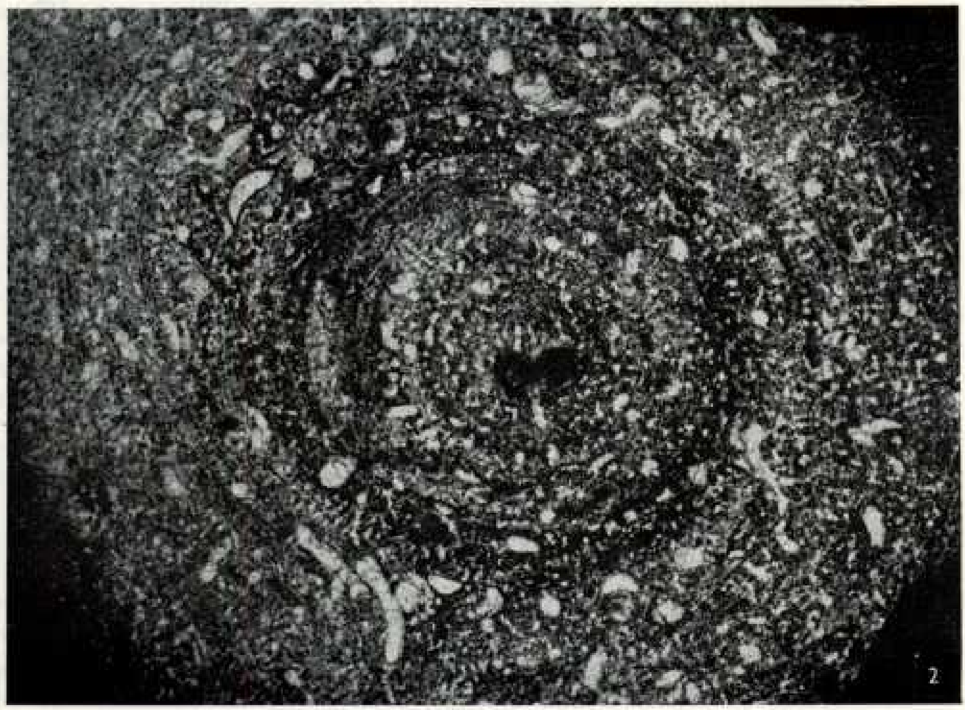
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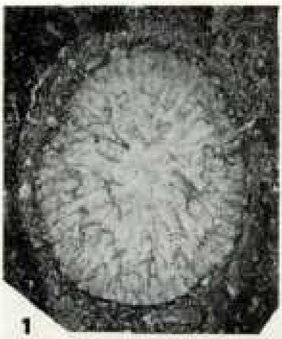
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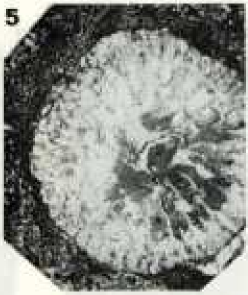
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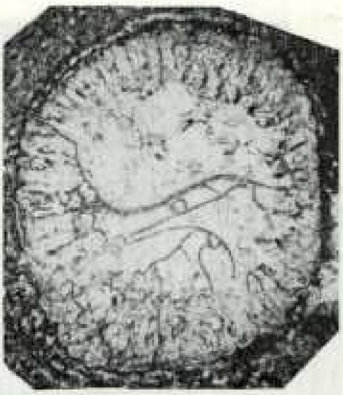
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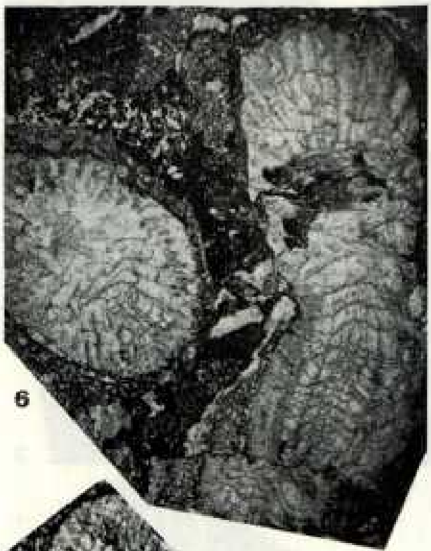
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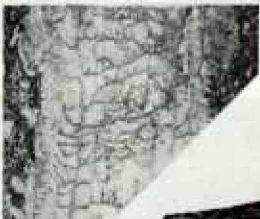
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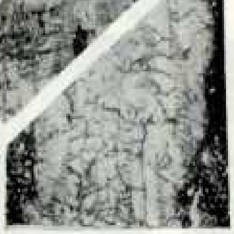
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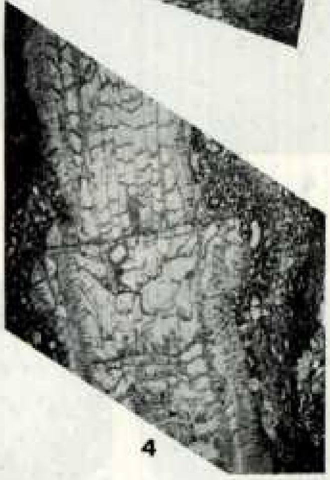
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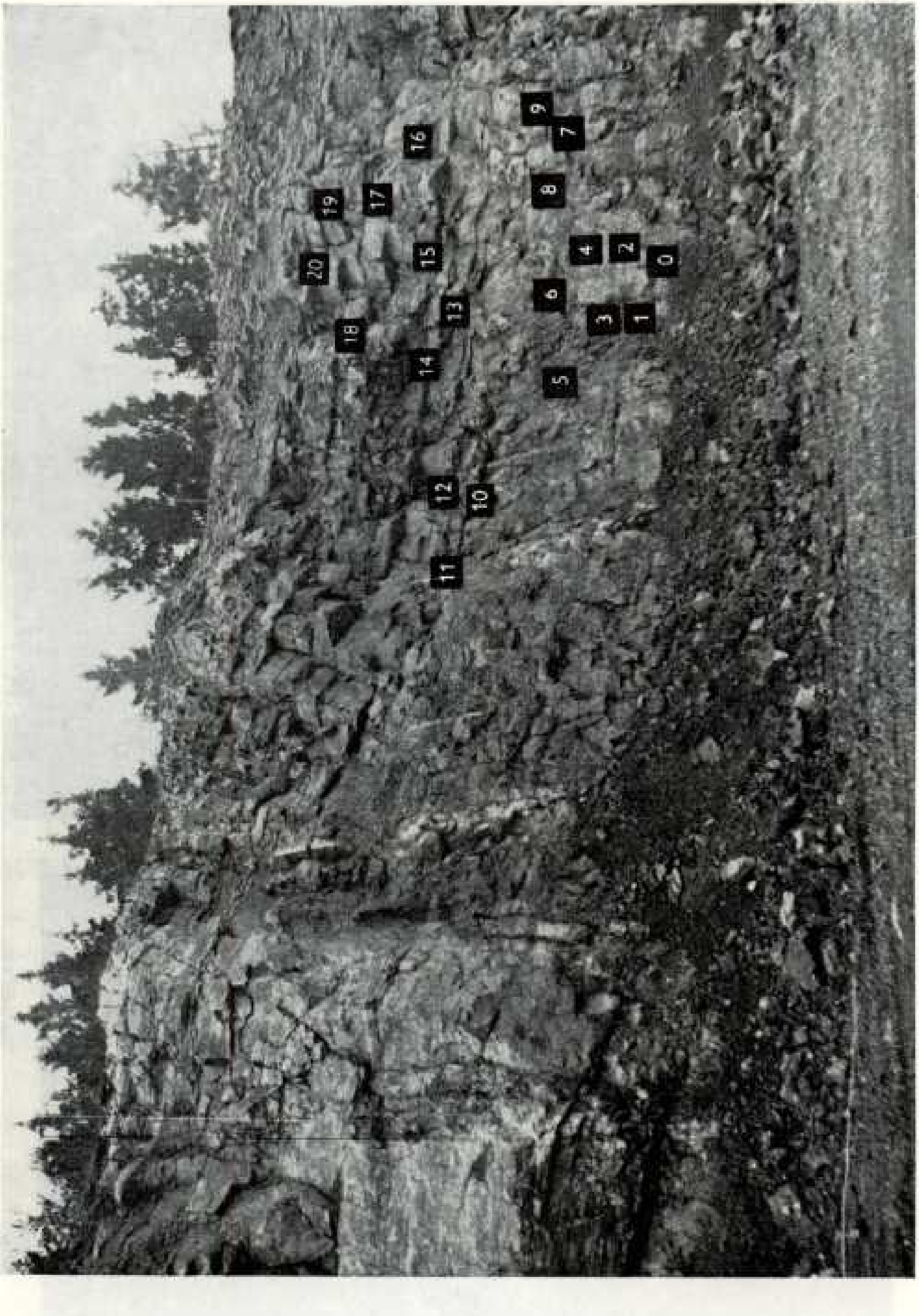
Pl. XII



10. *Polygnathus triphyllatus* (ZIEGLER), interval VII, Palmatolepis marginifera Zone, × 42.
11. *Polygnathus glaber glaber* ULRICH et BASSLER, interval VII, Palmatolepis marginifera Zone, × 95.

Pl. IV

1. *Polygnathus nodocostatus ovatus* HELMS, interval VII, Palmatolepis marginifera Zone, × 70.
2. *Nothognathella sublaevis* SANNEMANN, interval VIII, Palmatolepis marginifera Zone, × 75.
3. *Nothognathella condita* BRANSON et MEHL, interval V, Palmatolepis crepida Zone, × 90.
4. *Diplodella franca* (SANNEMANN), interval V, Palmatolepis crepida Zone, × 80.
5. *Polylophodonta linguiformis* BRANSON et MEHL, bed 20 B, Palmatolepis crepida Zone, × 95.
6. *Spathognathodus strigosus* (BRANSON et MEHL), interval VI, Palmatolepis crepida Zone, × 80.
7. *Ligonodina franconica* SANNEMANN, interval V, Palmatolepis crepida Zone, × 70.
8. *Nothognathella? falcata* HELMS, interval VIII, Palmatolepis marginifera Zone, × 70.
9. *Ozarcodina elegans* (STAUFFER), interval VI, Palmatolepis crepida Zone, × 70.
10. *Ozarcodina regularis* BRANSON et MEHL, interval VII, Palmatolepis marginifera Zone, × 60.

Pl. V

1. *Multiseptida* sp., sample from the bed 16, Geinitzina — Multiseptida foraminiferal zone No. 3, × 200.
2. *Multiseptida* sp., bed 16, Geinitzina — Multiseptida foraminiferal zone No. 3, × 200.
3. *Multiseptida* sp., bed 19, Geinitzina — Multiseptida foraminiferal zone No. 3, × 200.
4. *Multiseptida* sp., bed 16, Geinitzina — Multiseptida foraminiferal zone No. 3, × 150.
5. *Paratikhinella cannula* BYKOVA, internal VII, Septatournayella rauserae — Septabrunsiina foraminiferal zone No. 5, × 210.
6. *Caligella gracilis breviseptata* POYARKOV, interval VII, Septatournayella rauserae — Septabrunsiina foraminiferal zone No. 5, × 210.
7. *Caligella gracilis breviseptata* POYARKOV, the same level, × 210.
8. *Tournayellidae* indet., interval V, zone of unilocular foraminifers and Tournayellidae No. 4, × 210.
9. *Septabrunsiina* sp., top of the int. V, ?foraminiferal zone Septatournayella rauserae — Septabrunsiina No. 5, × 210.
10. *Sphaerocodium?* sp., interval VII, × 225.
11. *Auroria ferganensis* POYARKOV, interval VII, foram. zone Septatournayella rauserae — Septabrunsiina No. 5, × 225.
12. *Auroria ferganensis* POYARKOV, the same level, × 242.
13. *Auroria?* sp., the same level, × 225.

Pl. VI

1. *Scoliopora denticulata rachitiforma* HLADIL, bed 19, zone according to tabulate corals: Scoliopora denticulata vassinoensis, × 7.
2. *Scoliopora denticulata rachitiforma* HLADIL, *Amphipora tschussovensis* YAVORSKI, bed 17, zone according to tabulate corals: Scoliopora denticulata vassinoensis, × 7.

Pl. VII

1. *Scoliopora denticulata vassinoensis* DUBATOLOV, bed 17, zone according to tabulate corals: Scoliopora denticulata vassinoensis, × 7.
2. *Natalophyllum perspicuum* HLADIL, *Stromatopora* sp. and *Stromatoporella* sp., bed 20, zone according to tabulate corals: Scoliopora denticulata vassinoensis, × 5.

Pl. VIII

1. *Amphipora moravica* ZUKALOVÁ and *Solenoporaceae* indet. (top left), Amphipora-algal bed No. 3, zone according to stromatoporoids: Amphipora moravica — Syringostroma vesiculosum, × 9.

2. *Habrostroma* cf. *incrustans* (HALL et WHITEFIELD), bed 20, zone according to stromatoporoids: Amphipora moravica – Syringostroma vesiculosum, × 8.

Pl. IX

1–9. *Disphyllum veronika* GALLE, bed 17, zone according to rugose corals: Tabulophyllum maria – Alaiophyllum jana, × 3.3.

10, 11. *Alaiophyllum jana* GALLE, bed 17, zone according to rugose corals: Tabulophyllum maria – Alaiophyllum jana, × 3.3.

Pl. X

1–4. *Tabulophyllum maria* GALLE, bed 20A, zone according to rugose corals Tabulophyllum maria – Alaiophyllum jana, × 4.5.

5, 6. *Alaiophyllum jana* GALLE, beds 14 and 17, the same zone, × 4.5.

7–9. Sections of unidentifiable rugose corals, bed 14, the same zone, × 4.5.

Pl. XI

1. *Labechia cumularis* YAVORSKI, bed 5, × 3.
2. *Syringopora volkensis* TCHERNYSCHEV, bed 5, × 2.5.
3. *Tienodictyon* sp., bed 5, × 2.8.

Pl. XII

A general view of the face of the Western Quarry at Mokrá, the eastern, entrance part of the quarry. Beds numbered as shown on the picture. State of the face – November 1986.

Photographs by M. Molčík (I–IV), J. Kalvoda (V), ÚÚG – K. Navrátilová (VI–XI) and J. Hladil (XII).

# Fauna z vápenců při hranici frasn/famen v Mokré (devon, Morava, Československo)

*(Résumé anglického textu)*

Jindřich Hladil - Jiří Kalvoda - Olga Friáková - Arnošt Galle - Zuzana Krejčí

Předloženo 6. října 1986

V jižní části Moravského krasu, v. od Brna byl podrobně studován profil zachycující styk macošského souvrství (tvořeného karbonátovými nárůsty s útesovou faunou) a líšeňského souvrství (tvořeného poútesovou karbonátovou sedimentací). Ukončení tvorby karbonátových nárůstů a vymření útesotvorné fauny bylo datováno pomocí konodontů do vyšší části konodontové zóny Palmatolepis crepida, do spodního famenu.

Korálová a stromatoporoidová fauna, nalezená spolu s konodonty zóny Pa. crepida, může být použita pro korelaci spodního famenu v úsecích, kde konodonti v tomto údobí chybějí (např. jv. od Brna na paleozoické nítkovicko-němčičské platformě). Jde např. o druhy: *Natalophyllum perspicuum* Hladil, *Tabulophyllum maria* Galle, *Labechia cumularis* Yavorski a *Amphipora tschussovensis* Yavorski.

Sedimentační prostředí bylo charakterizováno jako postupně plošně se zmenšující mělká karbonátová rampa nebo komplex mělčin, dosti odkrytý vůči pánvi. Při bázi cyklů metrového řádu, které je možno vyčlenit v odkrytém sledu macošského souvrství, jsou temnější vápence s *Moravamminidae* indet., někdy s oogoniemi charofyt. V nižší části profilu tyto sedimenty nasedají na původní skalní dno. Vyšší části cyklů jsou světleji zbarveny, obsahují pestře tvarované úlomky útesotvorných organismů svazované jejich povlaky. Hojné jsou i laminované textury. Směrem do nadloží jsou častější výskyty konodontů, radiolárií (indikace kontaktu s pánevním prostorem), jinde i oogonií charofyt (kontakt s vyslazovanými příbřežními prostory).

Hranice frasnu a famenu je charakterizována podle stromatoporoidei a korálů. Je kladena mezi intervaly I a II, ca 4 m pod strop nárůstů. Za indikátory nesporných svrchofrasnských poloh jsou považovány poslední výskyty *Scoliopora kaisini* (Lecompte) a *Nanicella* sp.

## Фауна известняков при границе между франом и фаменом на м. Мокра (девон, Моравия, Чехословакия)

Рифовая фауна вымирает в профиле на м. Мокра в верхней части зоны конодонтов Palmatolepis crepida. В нижний фамен переходят особенно эврифациальные виды и сообщество показывает малую разнообразность. Понижение разнообразности ставят авторы в причинную связь с келльвассерскими эвстатическими и климатическими событиями, доказанными в настоящее время с общей точки зрения от средних уровней зоны Palmatolepis gigas по ее высшую часть (WALLISER 1985, 1986) и продолжающимися, возможно, до средних уровней зоны Palmatolepis triangularis (т. наз. Crickites event — см. KALVODA 1986). Граница между франом и фаменом проведена в профиле в стратиграфическом перерыве между интервалами I и II. Ниже упомянутого перерыва встречаются *Scoliopora kaisini* (LECOMPTE) и фораминифера *Nanicella* sp., значит, элементы, известные в Моравии до сих пор исключительно по кровлю зоны конодонтов Palmatolepis gigas, а выше него появляется уже *Labechia cumularis* YAVORSKI и *Syringopora volkensis* TCHERNYSCHEV, принимаемые авторами видов за элементы нижнефаменского возраста. Упомянутый стратиграфический перерыв охватывает, по всей вероятности, критический промежуток проведения границы между франом и фаменом, соответствующий нижней трети зоны Palmatolepis triangularis. В противоположность этому, выразительное изменение литологии между мацошской и лишеньской свитами (выше интервала IV) и вымирание сидячего бентоса (на 3—5 см ниже в профиле) не сопровождаются отсутствием биостратиграфических следов, так как лежачие и висячие пласты содержат автохтонные конодонты зоны Palmatolepis crepida, именно ее верхней части.

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# Palynology of the Nýřany Member (Westphalian D) in the Mšeno Basin

## Palynologie nýřanských vrstev mšenské pánve (vestfál D)

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Abstract: The Nýřany Member, the coal bearing horizon of the Lower Grey Formation in the Bohemian Carboniferous Basin was palynologically studied in the Mšeno Basin. In the coals here designated as Vavřineč group of seams rich assemblages of miospores and megaspores were established and systematically studied. Eleven species are probably new and described but not specifically named, others are referable or comparable to previously described types.

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### Introduction

In recent years palynological investigation of the Jelenice Member (Stephanian) has been done (1978). The present paper deals with the occurrence of megaspores and miospores of the Nýřany Member (Westphalian D) especially from the coals.

Geology: The Late Paleozoic Mšeno Basin occurs in the eastern continuation of the Central Bohemian Permo-Carboniferous in the area between Mělník, Dubá near Doksy, Mladá Boleslav and Nymburk. The Nýřany Member (Westphalian D) forms the basal part of the stratal sequence in the Carboniferous. [The underlying Radnice Member [Westphalian C] is only developed in a small south-western part of the basin in the Mělník area.] The Nýřany coal seams occur in four main coal bearing horizons in the lower two thirds of the Nýřany Member. The name of the Vavřineč group of seams was for them proposed (KALIBOVÁ-KAISEROVÁ 1982).

Material and methods: The samples of coals and claystones were obtained from boreholes drilled in the Mělník—Benátky area of the Mšeno Basin by the Geological Survey, Prague. The material was normally subjected to fumic nitric and hydrofluoric acid treatment for isolation of megaspores and miospores separately. Permanent slides were made in glycerin gel and were statistically analyzed.

## Spore systematics

The samples yielded a rich palynological assemblage comprising trilete and monolete spores, monosaccate and disaccate pollen grains.

The megaspores and miospores obtained have been placed under the following genera and species arranged according to the classification of POTONIÉ and KREMP (1954) supplemented by other workers.

As the botanical affinity of the genera occurring in the Jelenice Member was discussed in the publication concerning this Member (KALIBOVÁ 1978), in the Nýřany Member it is now discussed only at the genera that do not occur in the Jelenice Member.

Superdivisio (Anteturma) *Sporonites* (R. POTONIÉ) IBRAHIM 1933

Genus *Sporonites* IBRAHIM 1933

*S.* sp. (pl. XXIV, fig. 13)

Genus *Reticulatasporites* (IBRAHIM) POTONIÉ & KREMP 1954

*R.* sp. (pl. V, fig. 4)

Superdivisio (Anteturma) *Sporites* H. POTONIÉ 1893

Divisio (Turma) *Triletes* (REINSCH) POTONIÉ & KREMP 1954

Subdivisio (Subturma) *Azonotriletes* LUBER 1953

Genus *Leiotriletes* (Naumova) POTONIÉ & KREMP 1954

*L. adnatoides* POTONIÉ & KREMP 1956 (pl. I, figs. 8—9, pl. III, fig. 1)

Remarks: Nearly all specimens of the species are a little larger in size than stated in the diagnosis (30—40 μm). After PI-RADONDY - DOUBINGER (1968) the diameter ranges from 45—50 μm.
Prominent folds frequently accompany the laesurae.

*L. adnatus* (KOSANKE) POTONIÉ & KREMP 1954 (pl. I, figs. 1, 2)

*L. convexus* (KOSANKE) POTONIÉ & KREMP 1954 (pl. I, fig. 5)

*L. gulaferus* POTONIÉ & KREMP 1954 (pl. I, figs. 3, 6—7)

*L. sphaerotriangulus* (LOOSE) POTONIÉ & KREMP 1954 (pl. I, fig. 4)

*L. tumidus* BUTTERWORTH & WILLIAMS 1954 (pl. I, fig. 10; pl. III, fig. 2)

*L.* spp. (pl. I, fig. 11)

Genus *Punctatisporites* (IBRAHIM) POTONIÉ & KREMP 1954

*P. bifurcatus* KALIBOVÁ 1965 (pl. I, figs. 12—14)

*P.* cf. *minutus* KOSANKE 1950 (pl. I, fig. 16)

*P. obliquus* KOSANKE 1950

*P.* cf. *punctatus* IBRAHIM 1933 (pl. III, fig. 7)

*P.* spp. (pl. I, fig. 15, pl. XXIV, fig. 13)

Genus *Calamospora* SCHOPF, WILSON & BENTALL 1944

*C. breviradiata* KOSANKE 1950 (pl. III, figs. 5, 6)

*C.* cf. *liquida* KOSANKE 1950

*C. microrugosa* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944 (pl. I, figs. 21, 22, 24, pl. III, fig. 8)

*C. mutabilis* (LOOSE) SCHOPF, WILSON & BENTALL 1944 (pl. II, figs. 1—6, pl. III, fig. 10)

*C.* cf. *mutabilis* (LOOSE) SCHOPF, WILSON & BENTALL 1944 (pl. II, fig. 7)

*C. pallida* (LOOSE) SCHOPF, WILSON & BENTALL 1944 (pl. I, figs. 22, 23)

*C. parva* GUENNEL 1958 (pl. I, fig. 19)

*C. perrugosa* (LOOSE) SCHOPF, WILSON & BENTALL 1944

*C. pusilla* PEPPERS 1964

*C. saariana* BHARADWAJ 1957 (pl. I, figs. 17, 18)

*C. straminea* WILSON & KOSANKE 1944 (pl. III, figs. 13, 14)

*C.* sp. (pl. II, fig. 8)

Genus *Variouxisporites* ALPERN 1959

*V.* spp. (pl. IV, fig. 1, pl. XXIV, fig. 14)

Genus *Laevigatisporites* (IBRAHIM) POTONIÉ & KREMP 1954

*L. glabratus* (ZERNDT) POTONIÉ & KREMP sensu DIJKSTRA

Genus *Granulatisporites* (IBRAHIM) POTONIÉ & KREMP 1954

*G. granulatus* IBRAHIM 1933 (pl. V, figs. 5, 6)

*G.* cf. *granulatus* IBRAHIM 1933 (pl. IV, fig. 6)

*G. minutus* Potonié & Kremp 1955

*G.* cf. *minutus* Potonié & Kremp 1955

*G.* cf. *pannosites* Peppers 1964 (pl. VI, fig. 1)

*G. parvus* (Ibrahim) Potonié & Kremp 1955 (pl. IV, figs. 2, 3)

*G.* sp.

Genus *Cyclogranisporites* Potonié & Kremp 1954

*C. aureus* (Loose) Potonié & Kremp 1955 (pl. IV, figs. 8, 10–14; pl. V, figs. 2, 3)

*C.* cf. *aureus* (Loose) Potonié & Kremp 1955 (pl. V, fig. 8)

*C. jelenicensis* Kalibová 1978 (pl. III, fig. 3)

*C. orbicularis* (Kosanke) Potonié & Kremp 1955 (pl. IV, figs. 4, 7)

*C. orbiculus* Potonié & Kremp 1955

*C.* sp. A (pl. III, figs. 11, 12, 15; pl. IV, fig. 9; pl. V, fig. 1)

Description: Amb circular or subcircular due to secondary folds. Size 80–110 μm; suturae one-half of radius, grana 1 μm in diameter, 100–120 project at the margin.

Comparison: *Cyclogranisporites* sp. A has a finer ornament than *C. aureus*, which is also smaller in size (50–80 μm); in the work of Smith & Butterworth (1967) occasional specimens of *C. aureus* up to 99 μm have been recorded.

*C.* sp. (pl. IV, figs. 5, 15, 16)

Genus *Triletisporites* (R. Potonié) Potonié & Kremp 1954

Botanical affinity: Unknown.

*T. tuberculatus* (Zerndt) Potonié & Kremp 1954

Genus *Converrucosisporites* Potonié & Kremp 1954

*C.* sp.

?*C.* sp. (pl. VI, fig. 14)

Genus *Verrucosisporites* (Ibrahim) Smith & Butterworth 1967

*V.* cf. *compactus* Habib 1966 (pl. V, fig. 14)

*V. donarii* Potonié & Kremp 1955 (pl. V, fig. 15)

*V.* cf. *donarii* POTONIÉ & KREMP 1955 (pl. V, fig. 17; pl. VI, fig. 4)

*V. grandiverrucosus* (LOOSE) SMITH & al. 1964 (pl. V, fig. 22; pl. VI, fig. 8)

*V.* cf. *grandiverrucosus* (LOOSE) SMITH & al. 1964 (pl. VI, fig. 6)

*V. microtuberosus* (LOOSE) SMITH & BUTTERWORTH 1967 (pl. V, fig. 21)

*V. sifati* (IBRAHIM) SWITH & BUTTERWORTH 1967 (p. VI, fig. 9)

*V.* cf. *sinensis* IMGRUND 1952 (pl. VI, figs. 10,11)

*V. verrucosus* IBRAHIM 1933 (pl. V, fig. 23)

*V.* sp. A (pl. VI, figs. 2, 3)

Description: Amb circular, subcircular or oval. Size 40—48 μm. The trilete rays are distinct and equal in length to about two thirds of radius. Verrucae 1—2 μm in diameter.

Comparison: *Verrucosisporites* sp. A is similar to *V. cerosus* (HOFFMEISTER, STAPLIN and MALLOY) BUTTERWORTH and WILLIAMS, but is usually smaller in size and has more numerous verrucae.

*V.* sp. (pl. VI, fig. 5)

Genus *Kewaneesporites* PEPPERS 1970

*K.* sp. (pl. V, fig. 18)

Genus *Lophotriletes* (NAUMOVA) POTONIÉ & KREMP 1954

*L. gibbosus* (IBRAHIM) POTONIÉ & KREMP 1954 (pl. V, figs. 10, 11)

*L. pseudoaculeatus* POTONIÉ & KREMP 1955 (pl. V, fig. 14)

*L.* spp. (pl. V, figs.7, 12, 13)

Genus *Apiculatisporis* POTONIÉ & KREMP 1955

*A. abditus* (LOOSE) POTONIÉ & KREMP 1955 (pl. V, fig. 19)

*A. setulosus* (KOSANKE) POTONIÉ & KREMP 1954

*A. variusetosus* (PEPPERS) KALIBOVÁ 1978 (pl. VII, figs. 1—3)

*A.* sp. (pl. V, fig. 20)

?*A.* sp.

Genus *Acanthotriletes* (NAUMOVA) POTONIÉ & KREMP 1954

*A.* sp.

Genus *Apiculatasporites* (IBRAHIM) SMITH & BUTTERWORTH 1967

*A. spinulistratus* (LOOSE) IBRAHIM 1933 (pl. VI, figs. 16–18)

Genus *Planisporites* (KNOX) POTONIÉ 1960

*P.* spp. (pl. VI, figs. 12–15; pl. VII, figs. 4–6)

Genus *Pustulatisporites* POTONIÉ & KREMP 1954

*P. crenatus* GUENNEL 1958 (pl. V, fig. 9)

Genus *Tuberculatisporites* (IBRAHIM) POTONIÉ & KREMP 1955

*T. mamillarius* (BARTLETT) POTONIÉ & KREMP 1955

Genus *Raistrickia* (SCHOPF, WILSON & BENTALL) POTONIÉ & KREMP 1954

*R. aculeata* KOSANKE 1950 (pl. IX, figs. 12, 13)

*R. aculeolata* WILSON & KOSANKE 1944 (pl. VIII, figs. 10, 11; pl. IX, figs. 1–5)

*R.* cf. *aculeolata* WILSON & KOSANKE 1944 (pl. IX, figs. 14–17)

*R. crinita* KOSANKE 1950 (pl. IX, fig. 8)

*R.* cf. *crinita* KOSANKE 1950 (pl. VIII, fig. 9)

*R.* cf. *crocea* KOSANKE 1950 (pl. IX, fig. 11)

Description: Spore circular to oval, 45–60 μm in size. Trilete rays not visible. Exine is covered with regularly spaced bacula 8–12 μm in length and 2.5–6 μm in width, occasionally twisted.

Comparison: *R. crocea* is very similar, but usually greater in size and has longer and wider bacula. Approximately 15 projections extend beyond the spore margin.

*R.* cf. *dispar* PEPPERS 1970 (pl. IX, figs. 7, 9, 10)

Description: Amb roundly triangular. Laesurae simple, about three fourths of the radius. The spore coat is covered with not closely spaced projections of various shapes and sizes, 2–6 μm wide at their bases and 3–6 μm long. About 20–30 ornaments extend beyond the margin.

Comparison: The projections of *R. dispar* are more closely spaced.

*R.* cf. *fibrata* (pl. VIII, fig. 4)

*R. lacerata* PEPPERS 1970 (pl. VIII, figs. 13, 17)

*R.* cf. *lacerata* PEPPERS 1970 (pl. VIII, fig. 12)

*R. solaris* WILSON & HOFFMEISTER 1956 (pl. VIII, fig. 19)

*R. superba* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944 (pl. VIII, figs. 2, 3)

*R.* cf. *superba* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944 (pl. VIII, fig. 5)

Description: Amb round to oval; leasurae three quarters of radius. Ornaments irregularly distributed; at their top ends the bacula are rounded. 20 – 30 projecting from the margin.
Comparison: They agree with *R. superba* in possessing various types of ornament of variable density, but not including cone-shaped bacula.

*R.* sp. A (pl. VIII, fig. 6)

Description: Amb roundedly triangular, size 40 – 45 μm. Suturae simple, about two thirds of radius. Ornament of bacula, 8 – 10 μm in length and 3 – 4 μm in breadth, 15 – 20 occur around the margin.
Comparison: *R.* sp. A differs from other species in its form and relatively large bacula.

*R.* sp. B (pl. VIII, figs. 14 – 16, 18)

Description: Amb circular to subcircular, size 60 – 70 μm, suturae simple, one half of radius. Bacula about 4 μm in length, taper from the base and are rounded; they almost cover the entire exine, bases may be in contact.
Comparison: *R.* sp. B differs from *R. aculeata* mainly in possessing broader and closely spaced processes.

*R.* spp. (pl. VIII, fig. 1)

?*R.* cf. *baculata* KALIBOVÁ 1978 (pl. IX, fig. 6)

Description: Amb circular, size 75 – 85 μm, suturae not visible. Club-shaped processes are closely spaced and are not longer than wide. They have coarsely reticulate appearance. Their apices are flat or rounded.
Comparison: *R. baculata* is smaller in size.
Remarks: ?*R. baculata* has been assigned to the genus *Raistrickia* provisionally for the different shape of processes. (The character of the bacula is comparable to that described by BHARADWAJ (1955) in the genus *Cyclobaculisporites*, which is invalid because the ornament of the holotype *C. grandiverrucosus* BHARADWAJ is verrucose.)

Genus *Microreticulatisporites* (KNOX) POTONIÉ & KREMP 1954 non sensu BHARADWAJ 1955

*M. nobilis* (WICHER) KNOX 1950 (pl. X, figs. 1—4)

*M.* spp. (pl. VII, fig. 8; pl. X, fig. 13)

Genus *Convolutispora* HOFFMEISTER, STAPLIN & MALLOY 1955

*C.* sp. 2 PEPPERS 1970

Description: The spore is radial and subcircular in outline. The suture is indistinct. The exine is covered with irregular obvermiculate ridges 3.5 μm in height. Size 45—52 μm.

Comparison: After PEPPERS (1970) *C.* sp. 2 is quite similar to the specimen described by HOFFMEISTER, STAPLIN and MALLOY (1955) as *Convolutispora* type A.

*C.* sp. B (pl. X, figs. 6, 7)

Description: Amb subcircular to oval, size 48—60 μm. The trilete rays are straight and extend to two thirds of the length of the radius. Vermiculate ridges on the spore surface are videly spaced and are up to 5 μm wide and 3 μm tall.

Comparison: *Convolutispora* sp. B is comparable with *C. florida* HOFFMEISTER, STAPLIN & MALLOY 1955 which has a relatively coarse ornament, and with *C.* sp. 2 PEPPERS 1964 which is smaller in size.

*C.* spp. (pl. X, figs. 8, 9)

Genus *Reticulatisporites* (IBRAHIM) POTONIÉ & KREMP 1954

*R. lacunosus* KOSANKE 1950 (pl. X, figs. 15, 16)

*R. muricatus* KOSANKE 1950 (pl. X, fig. 17)

Genus *Savitrisporites* BHARADWAJ 1955

*S. majus* BHARADWAJ 1957 (pl. X, fig. 12)

*S.* sp.

Genus *Camptotriletes* (NAUMOVA) POTONIÉ & KREMP 1954

*C.* sp.

Genus *Dictyotriletes* (NAUMOVA) POTONIÉ & KREMP 1954

*D. mediareticulatus* (IBRAHIM) POTONIÉ & KREMP 1955 (pl. X, fig. 11)

*D. camptotus* ALPERN 1958

Genus *Knoxisporites* POTONIÉ & KREMP 1954

*K.* sp.

Genus *Triquitrites* (WILSON & COE) POTONIÉ & KREMP 1954

*T. bransonii* WILSON & HOFFMEISTER 1956 (pl. XI, figs. 7—11)

*T.* cf. *bransonii* WILSON & HOFFMEISTER 1956 (pl. XI, figs. 13—18)

Remarks: Spores distinguish from *T. bransonii* by shortes suturae, extending to two thirds till three quaters of the radius.

*T. bucculentus* GUENNEL 1958 (pl. XI, figs. 1—3)

*T. exiguus* WILSON & KOSANKE 1944 (p. XI, figs. 4—6)

*T. pulvinatus* KOSANKE 1950 (pl. XI, fig. 23)

*T. verrucosus* ALPERN 1959 (pl. XI, figs. 31—33)

*T. sculptilis* (BALME) SMITH & BUTTERWORTH 1967

*T.* spp. (pl. XI, figs. 12, 19, 28)

Genus *Firmysporites* PI-RADONDY & DOUBINGER 1968

Botanical affinity: Unknown.

*F. irregularis* PI-RADONDY & DOUBINGER 1968 (pl. XI, figs. 26, 27)

Genus *Ahrensisporites* POTONIÉ & KREMP 1954

*A.* sp. (pl. XI, fig. 34)

Genus *Mooreisporites* NEVES 1958

Botanical affinity: Unknown.

*M. inusitatus* (KOSANKE) NEVES 1958 (pl. XIV, fig. 19)

*M.* cf. *inusitatus* (KOSANKE) NEVES 1958 sensu SMITH & BUTTERWORTH 1967 (pl. XIV, figs. 16—18)

Remarks: Few specimens are smaller in size (50—60 μm) than *M. inusitatus* and correspond with *M.* cf. *inusitatus* by SMITH & BUTTERWORTH 1967.

Genus *Valvisisporites* (IBRAHIM) LACHKAR 1968

*V. auritus* (ZERNDT) BHARADWAJ 1957

Subdivisio (Subturma) *Zonotriletes* WALTZ 1945

Genus *Lycospora* (SCHOPF, WILSON & BENTALL) POTONIÉ & KREMP 1954

*L. brevijuga* KOSANKE 1950 (pl. XII, figs. 6, 9, 10)

*L. brevis* BHARADWAJ 1957

*L. denticulata* BHARADWAJ 1957

*L. granulata* KOSANKE 1950 (pl. XII, fig. 9, 10)

*L. parva* KOSANKE 1950 (pl. XII, figs. 16—18)

*L.* cf. *pressoides* POTONIÉ & KREMP 1956 (pl. XII, figs. 21, 22)

*L. pseudoannulata* KOSANKE 1950 (p. XI, figs. 1, 2)

*L. punctata* KOSANKE 1950 (pl. XII, figs. 3—5)

*L. pusilla* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944 (pl. XII, figs. 8, 11, 12)

*L. subjuga* BHARADWAJ 1957 (pl. XII, fig. 20)

*L. triangulata* BHARADWAJ 1957

*L.* spp. (pl. XI, fig. 31; pl. XII, fig. 14)

Genus *Stenozonotriletes* (NAUMOVA) POTONIÉ 1958

Botanical affinity: Unknown.

*S. lycosporoides* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH 1967 (pl. XII, fig. 15)

Genus *Crassispora* BHARADWAJ 1957

*C. kosankei* (POTONIÉ & KREMP) BHARADWAJ 1957 (pl. XII, fig. 23)

*C.* sp.

Genus *Densosporites* (BERRY) POTONIÉ & KREMP 1954

*D. sphaerotriangularis* KOSANKE 1950 (pl. XI, fig. 38)

*D.* sp.

Genus *Cadiospora* (KOSANKE) VENKATACHALA & BHARADWAJ 1964

*C. magna* (KOSANKE) KALIBOVÁ 1978

*C. magna* forma *minor* Kalibová 1978 (pl. XVI, fig. 6)

*C. magna* forma *maior* Kalibová 1978 (pl. XII, fig. 27, pl. XIII, figs. 1 –6)

*C. butterworthi* (Kalibová) Kalibová 1972 (pl. XII, fig. 28)

Genus *Gillespieisporites* Clendening 1969

*G. discoideus* (Kosanke) Kalibová 1978 (pl. XIV, figs. 5, 7 –12)

Remarks: Some specimens are developed in gulaferous form.

*G. spinosus* Kalibová 1978 (pl. XI, figs. 29, 30; pl. XIV, figs. 1 –4, 14, 15)

Genus *Vestispora* (Wilson & Hoffmeister) Wilson & Venkatachala 1963

Botanical affinity: Spores of the character of *Vestispora* have been found in ? *Noeggerathiopsida* (Levittan and Barghoorn 1948) and in *Sphenopsida* (Mamay 1954, Remy 1955, Remy 1959 and Brush & Barghoorn 1964).

*V. costata* (Balme) Spode 1968 (pl. XV, figs. 1 –8, 15)

*V. fenestrata* (Kosanke & Brokaw) Wilson & Venkatachala 1963 (pl. XV, figs. 13, 14; pl. XII, fig. 30)

*V. pseudoreticulata* Spode 1968 (pl. XV, fig. 12)

*V. quaesita* (Kosanke & Brokaw) Wilson & Venkatachala 1963 (pl. XII, figs. 24 –26)

*V.* cf. *profunda* Wilson & Hoffmeister 1956 (pl. XV, figs. 9 –11)

Genus *Westphalensisporites* Alpern 1959

Botanical affinity: Unknown.

*W. irregularis* Alpern 1959 (pl. XI, fig. 35)

Genus *Bentzisporites* (Zerndt) Potonié & Kremp 1954

*B. tricollinus* (Zerndt) Potonié & Kremp 1954

Genus *Cirratriradites* Wilson & Coe 1940

Botanical affinity: Zeiller (1900) and later Chaloner (1954) found the forms of *Cirratriradites* at *Selaginellites suissei* Zeiller and Hoskins & Abbott (1956) at *Selaginellites crassicinctus* Hoskins & Abbott (*C. anulatus* Kosanke & Brokaw) together with megaspores corresponding with *Triangulatisporites triangulatus* (Zerndt) Potonié & Kremp.

*C. saturni* (Ibrahim) Schopf, Wilson & Bentall 1944 (pl. XVI, figs. 2 –5)

*C. annuliformis* Kosanke & Brokaw 1950 (pl. XVI, figs. 7 –8)

Genus *Angulisporites* BHARADWAJ 1954

Botanical affinity: Unknown.

*A.* sp. (pl. XVI, fig. 1)

Genus *Triangulatisporites* POTONIÉ & KREMP 1954

Botanical affinity: *Selaginellites suissei* ZEILLER (LACHKAR 1971) contains spores of the type *Triangulatisporites*. They were also found at *S. primaevus* (GOLDENBERG) HALLE and *S. crassicinctus* HOSKINS & ABBOTT (1956).

*T. triangulatus* (ZERNDT) POTONIÉ & KREMP 1954

Subdivisio (Subturma) *Lagenotriletes* (POTONIÉ & KREMP) BHARADWAJ 1957

Genus *Lagenoisporites* (LOOSE) POTONIÉ & KREMP 1954

*L. rugosus* (LOOSE) POTONIÉ & KREMP 1954

Subdivisio (Subturma) *Cystites* POTONIÉ & KREMP 1954

Genus *Cystosporites* SCHOPF 1938

*C. giganteus* (ZERNDT) SCHOPF 1938

*C. varius* (WICHER) DIJKSTRA 1946

Divisio (Turma) *Monoletes* IBRAHIM 1933

Subdivisio (Subturma) *Azonomonoletes* LUBER 1935

Genus *Laevigatosporites* IBRAHIM 1933

*L. desmoinesensis* (WILSON & COE) SCHOPF, WILSON & BENTALL 1944

*L. medius* KOSANKE 1950

*L.* cf. *medius* KOSANKE

*L.* sp. C KALIBOVÁ 1963 (pl. XVII, fig. 1)

Remarks: The spore designated as *Laevigatosporites* sp. C characterises a thick fold parallel with the longitudinal axis of the spore.

*L.* sp. D KALIBOVÁ 1963 (pl. XVII, fig. 2)

Remarks: *Laevigatosporites* sp. D I have designated the spores of the size range of 15—21 μm.

*L.* sp. E KALIBOVÁ 1970

Remarks: *Laevigatosporites* sp. E was described from the borehole MB-5 (KALIBOVÁ 1970). The size is 62 × 35 μm, monolete mark one half of radius,spots sparsely scattered on the exine.

*L.* sp. (pl. XVII, fig. 2)

Genus *Latosporittes* POTONIÉ & KREMP 1954

*L. globosus* (SCHEMEL) POTONIÉ & KREMP 1956

*L.* cf. *globosus* (SCHEMEL) POTONIÉ & KREMP (pl. XVII, fig. 23)

Remarks: As *L.* cf. *globosus* I designate the specimens with monolete mark longer than two thirds of the spore diameter.

*L. latus* (KOSANKE) POTONIÉ & KREMP 1956

*L.* sp.

Genus *Punctatosporites* IBRAHIM 1933

*P. minutus* IBRAHIM 1933

*P. oculus* SMITH & BUTTERWORTH 1967

*P. pygmaeus* (IMGRUND) POTONIÉ & KREMP 1956 (pl. XVII, figs. 8, 9)

*P. speciosus* KALIBOVÁ 1970 (pl. XVII, figs. 3—7)

*P.* sp. (pl. XIV, fig. 5)

Genus *Spinosporites* ALPERN 1959)

Botanical affinity: Unknown.

*S. spinosus* ALPERN 1959 (pl. XVII, fig. 21)

*S.* sp. (pl. XVII, fig. 22)

Genus *Speciososporites* POTONIÉ & KREMP 1954

*S. minor* ALPERN 1959 (pl. XVII, figs. 10—17)

*S. infrapunctatus* KALIBOVÁ 1978 (pl. XVII, figs. 19, 20)

?*S.* cf. *triletoides* ALPERN 1959 (pl. XVII, fig. 18)

*S.* sp.

Superdivisio (Anteturma) *Pollenites* POTONIÉ 1941

Divisio (Turma) *Saccites* ERDTMAN 1947

Subdivisio (Subturma) *Monosaccites* (CHITALEY) POTONIÉ & KREMP 1954

Genus *Endosporites* WILSON & COE 1940

*E. formosus* KOSANKE 1950 (pl. XIV, fig. 5, pl. XVIII, figs. 1, 2)

*E.* cf. *globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944 (pl. XVIII, fig. 7)

*E.* sp. (pl. XVIII, fig. 10)

Genus *Microsporites* DIJKSTRA 1946 (= *Spencerisporites* CHALONER 1951)

*M. gracilis* (ZERNDT) DIJKSTRA 1946

Genus *Wilsonites* KOSANKE 1950

*W. delicatus* KOSANKE 1950 (pl. XVIII, fig. 4, 8)

*W. vesicatus* KOSANKE 1950 (pl. XVIII, fig. 3)

*W.* spp. (pl. XVIII, figs. 5, 9, 11; pl. XXIV, fig. 3)

Genus *Latensina* LUBER 1953

*L. triletus* ALPERN 1959

*L.* sp. (pl. XVII, figs. 28, 29, 31, 32)

Genus *Florinites* SCHOPF, WILSON & BENTAL 1944

*F. antiquus* SCHOPF 1944 (pl. XIX, fig. 9)

*F.* cf. *diversiformis* KOSANKE 1950 (pl. XX, fig. 1)

*F. junior* POTONIÉ & KREMP 1956

*F. mediapudens* (LOOSE) POTONIÉ & KREMP 1956 (pl. XXI, fig. 4)

*F.* cf. *mediapudens* (LOOSE) POTONIÉ & KREMP 1956 (pl. XIX, fig. 12)

*F. piérarti* KALIBOVÁ 1965 (pl. XIX, fig. 8)

*F. plicatus* KALIBOVÁ 1965 (pl. XIX, figs. 5–9, pl. XX, fig. 3)

*F. pumicosus* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944

*F. similis* KOSANKE 1950 (pl. XIX, fig. 4)

*F. visendus* (IBRAHIM) SCHOPF, WILSON & BENTALL 1944

*F.* cf. *volans* (LOOSE) POTONIÉ & KREMP 1956

*F.* spp. (pl. XIX, fig. 1, 10, 11; pl. XX, fig. 2)

Genus *Potonieisporites* (BHARADWAJ) BHARADWAJ 1964

Remarks: BHARADWAJ (1964) discusses the morphology, systematics and stratigraphy of *Potonieisporites*. He reports that the form of *Potonieisporites* extends from circular coronal to increasingly bilateral. He considers it proven that *Sahnisporites* PANT 1955 is indistinguishable from *Potonieisporites* and thus concludes that *Sahnites* is a synonym of *Potonieisporites*. HART (1965) places *Sahnites* in part to *Vestigisporites* (BALME and HENNELLY) HART 1960, and in part to *Limitisporites* (LESCHIK) POTONIÉ 1958. Some specimens of *Florinites* SCHOPF, WILSON & BENTALL 1944 are mistaken easily for some specimens of *Potonieisporites* when the former does not possess visible suturae, or when the latter does not possess a monolete mark. NYGREEN and BOURN (1967) describe and illustrate numerous specimens of *Potonieisporites* from a single sample, which show a wide range of morphological variations. The germinal feature of the material studied exhibits considerable variation in form, beginning as a rectilinear monolete mark and ending as a trilete mark.

*P. novicus* BHARADWAJ 1954 (pl. XXI, fig. 3; pl. XXII, fig. 1)

*P. novicus* forma *grandis* KALIBOVÁ 1978 (pl. XXI, figs. 2, 5; pl. XXII, figs. 2, 3)

*P.* cf. *elegans* (WILSON & KOSANKE) WILSON & VENKATACHALA 1964

*P.* spp. (pl. XIX, fig. 1; pl. XX, fig. 5; pl. XXI, fig. 1)

?*Potonieisporites* sp. (pl. XII, fig. 1; pl. XXIV, fig. 2)

Genus *Bascanisporites* BALME & HENNELLY 1956

*B. parvisaccus* PI-RADONDY & DOUBINGER 1967 (pl. XVII, fig. 27)

Genus *Candidispora* VENKATACHALA 1961

Botanical affinity: Unknown.

*C.* cf. *candida* VENKATACHALA 1961 (pl. XIX, fig. 2)

### Subdivisio (Subturma) *Disaccites* COOKSON 1947

Remarks: Disaccate *Pollenites* underwent a period of explosive evolution at the end of the Paleozoic era and one finds numerous differentiating lines evolving. A consequence of this is that many of the early forms are difficult to sub-divide into series (infraturma), genera, or often species.

Many genera and species were lately described. In the late Carboniferous there are scarce finds and it is not easy to differentiate the species. Some palynologists described their specimens and proposed them as new species, others compared their find with the known species or announced them only with a question mark.

The three series (indraturmae) Disacciatrileti, Disaccitrileti and Striatiti are easy to differentiate and can be conveniently dealt with as a distinct group. Finer subdivisions appear not to be useful for Carboniferous miospores.

### Genus *Alisporites* DAUGHERTY 1941

Botanical affinity: The spores found in *Caytoniales* (by HARRIS 1941 in *Caytonanthus oncodes*) have the character of *Alisporites.*

*A.* sp. A (pl. XXIII, figs. 6, 7)

Description: Bisaccate spore roundedly tetragonal or broadly circular, central body vertically oval; a vertical slit lying transversely to the long axis of the spore. Size 50—60 × 35—40 μm. Bladders intrareticulate, with single folds.

Comparison: *Alisporites* is closely related with *Illinites* and differs from it in having trilete mark on the proximal side (not always visible). *Alisporites saarensis* BHARADWAJ is very similar to *A.* sp. A, but smaller in size.

### Genus *Vesicaspora* (SCHEMEL) WILSON & VENKATACHALA 1963

Botanical affinity: Unknown.

Remarks: From the emended diagnosis by the authors it is not clear that *Vesicaspora* can be well distinguished from other genera.

*V.* sp. A (pl. XXIII, figs. 8, 10)

Description: Spores with circular overall shape, 70—80 μm in size. Central body faintly discernible, outline not defined. The median region shows vertical folds frequently. Sacci distally inclined and mostly infolded in a characteristic way, saccus exine infrareticulate.

*V.* sp. (pl. XVII, fig. 30)

### Genus *Sulcatisporites* (LESCHIK) BHARADWAJ 1960

*S.* spp.

Single finds of various size can be assigned to this genus.

Genus *Tumoripollenites* BHARADWAJ 1960

Botanical affinity: The structure of the body has the character of *Podocarpaceae* (POTONIÉ 1966).

*T.* cf. *baccatus* BHARADWAJ 1960 (pl. XXIV, fig. 6)

Description: Bisaccate spores, size 75–80 µm, with circular to oval central body, 35–40 µm in diameter, bearing tubercles with rounded heads, more numerous nearer the equator and less as well as smaller nearer the centre.

Comparison: *Tumoripollenites baccatus* differs from *T.* cf. *baccatus* in having sacci smaller than the central body.

*T.* sp. A (pl. XXIV, figs. 4, 5, 9)

Description: Bisaccate spores 50–68 µm in diameter, central body 30 to 40 µm, circular to horizontally oval, proximally thickwalled, bearing close and uniformly spaced bacula-like tubercles, up to 4 µm broad, with rounded heads. A split on a fold running along the longest axis. Sacci infrareticulate and distally attached.

Comparison: Tumoripollenites baculatus is greater in size and has sacci smaller than the central body in height.

Genus *Illinites* KOSANKE 1950

Botanical affinity: REIMANN (1975) mentioned the possible relation of *Illinites* with *Callipteris conferta* STERNBERG.

*I.* sp. A (pl. XXIII, figs. 12, 16)

Description: Bisaccate miospore, size 70–85 µm, central body 34–40 µm × × 40–50 µm, ellipsoid, having a narrow sulcus on the distal side parallel to the lateral axis. Bladders are intrareticulate, equatorially attached to central body on proximal side. Trilete mark is not visible.

Comparison: *Illinites unicus* KOSANKE is smaller and has distinct trilete mark. The spores are also comparable with the spores described by BHARADWAJ (1955) as *Kosankeisporites*, distinguishing from *Illinites* by zigzag rugulae and the sulcus having been formed due to overlapping of the bladder upon the central body.

Genus *Striatites* (PANT) BHARADWAJ 1960

*S.* sp.

Genus *Protohaploxypinus* (SAMOILOVICH) HART 1964

? *P.* sp. (pl. XXIV, fig. 11)

Description: Bisaccate striate spore, haploxylonoid or slightly diploxylonoid in outline, 90–100 µm long and 50–58 µm wide. The central body is oval. The proximal cap possesses six or more longitudinal ribs in polar view. The sacci are about semi-circular in shape and smaller than the central body in size. The sacci structure is infrareticulate.

Remarks: Striate grains previously assigned to *Lueckisporites* POTONIÉ & KLAUS 1954, *Lunatisporites* LESCHIK 1956 and *Striatites* PANT 1955 are synonyms of *Protohaploxypinus*.

Genus *Kosankeisporites* BHARADWAJ 1955

*K. elegans* (KOSANKE) BHARADWAJ 1955

? *K.* sp. A (pl. XXIV, fig. 10)

Description: Bisaccate miospores 90—100 μm × 65—70 μm with two large, distally inclined bladders, infrareticulate with small mesches not exceeding 1 μm in diameter. Central body oval, on the proximal side the surface shows thin grooves (rugulae); the sulcus on the distal side parallel to the lateral side is not distinguished.

Comparison: *Kosankeisporites elegans* is smaller in size and its central body is characterized by the presence of a wall-shaped sulcus on distal side. The genus *Illinites* can be distinguished by having trilete mark and lack of rugulae on the proximal side.

Comparison: *Illinites unicus* KOSANKE is smaller in size (56—70 μm) and has distinct trilete mark. *Illinites* sp. A is also comparable with the spores described by BHARADWAJ (1955) as *Kosankeisporites*, distinguishing from *Illinites* by zigzag rugulae and the sulcus having been formed due to overlapping of the bladder upon the central body.

Genus *Limitisporites* LESCHIK 1956

Botanical affinity: Unknown.

*L.* sp. A (pl. XXIII, figs. 2, 3)

Description: Bisaccate miospore oval, 60—75 × 55—60 μm in size, central body distinct, 42—55 × 30—40 μm, laevigate. Monolete mark well-developed, extending nearly the central body. Proximal attachment of saccus to central body equatorial. Saccus intrareticulate.

Comparison: *Limitisporites* sp. A resembles *L. plicatus* BOSE & CAR. and *T. leschiki* KLAUS, of which it is distinguished by its large size.

*L.* sp. (pl. XXII, figs. 4, 6; pl. XXIII, fig. 4)

Subdivisio (Subturma) *Polysaccites* COOKSON 1947

Genus *Alatisporites* IBRAHIM 1933

*A.* sp.

Divisio (Turma) *Plicates* POTONIÉ 1960

Subdivisio (Subturma) *Praecolpates* POTONIÉ & KREMP 1954

Genus *Schopfipollenites* POTONIÉ & KREMP 1954

*S. ellipsoides* (IBRAHIM) POTONIÉ & KREMP 1954 (pl. XVI, fig. 11)

Subdivisio (Subturma) *Polyplicates* ERDTMAN 1952

Genus *Vittatina* (Luber) WILSON 1962

Botanical affinity: probably of *Welwitschiaceae.*

?*Vittatina* sp. (pl. XXIV, fig. 7)

The miospore floras of the coal seams are rich in species, most of which are considered to be derived from vegetation growing within the basin of peat deposition. Only few miospores are transported from distant sources.

The miospore assemblages are dominated by the genus *Lycospora,* which is with its 44 % the commonest. *Laevigatosporites* and *Punctatosporites* are next in abundance and each represents 11,9 % of the assemblage total. Also *Calamospora* and *Triquitrites* become significant members of the miospore floras and are represented by frequency of 5.5 and 5.7 %. The miospore *Endosporites formosus* with the megaspore *Valvisisporites auritus* may be locally common. Stratigraphically important *Vestispora costata, V. fenestrata* and *V. qaesita* are more or less equally distributed (3 %). It is interesting to note that *Cirratriradites saturni* only exceptionally occurs in the frequency greater than 1 % and is often absent. There are horisons reaching higher percentage in the species of *Punctatisporites* (average 3 %) and *Florinites* (average 7 %). The typical species of *Raistrickia* are meagerly represented. Bisaccate spores are commonly present in higher coals. Other genera with various species were locally distributed in small frequency. The most common species of megaspores are *Lagenoisporites rugosus* and *Triangulatisporites triangulatus.* More interesting is the lack of *Tuberculatisporites mamillarius* and the occurrence of *Laevigatisporites glabratus* and a low number of *Triletisporites tuberculatus* in the lowest coals.

Table 1

Occurrence of the miospore and megaspore species in the Nýřany Member

| | |
|---|---|
| *Sporonites* sp. | x |
| *Reticulatasporites* sp. | x |
| *Leiotriletes adnatoides* | xx |
| *Leiotriletes adnatus* | xx |
| *Leiotriletes convexus* | x |
| *Leiotriletes gulaferus* | xx |
| *Leiotriletes sphaerotriangulus* | x |
| *Leiotriletes tumidus* | xx |
| *Punctatisporites bifurcatus* | xx |
| *Punctatisporites* cf. *minutus* | x |
| *Punctatisporites obliquus* | x |
| *Punctatisporites* cf. *punctatus* | x |
| *Calamospora breviradiata* | xx |
| *Calamospora* cf. *liquida* | x |
| *Calamospora microrugosa* | xx |
| *Calamospora mutabilis* | xx |
| *Calamospora* cf. *mutabilis* | xx |
| *Calamospora pallida* | xx |
| *Calamospora parva* | x |
| *Calamospora perrugosa* | x |
| *Calamospora pusilla* | x |
| *Calamospora saariana* | xx |
| *Calamospora straminea* | xx |
| *Variouxisporites* spp. | xx |
| *Laevigatisporites glabratus* | xxx |
| *Granulatisporites granulatus* | xx |
| *Granulatisporites* cf. *granulatus* | x |
| *Granulatisporites minutus* | x |
| *Granulatisporites* cf. *minutus* | x |
| *Granulatisporites* cf. *pannosites* | x |
| *Granulatisporites parvus* | xx |
| *Cyclogranisporites aureus* | xx |
| *Cyclogranisporites* cf. *aureus* | xx |
| *Cyclogranisporites jelenicensis* | x |
| *Cyclogranisporites orbicularis* | xx |
| *Cyclogranisporites orbiculus* | x |
| *Cyclogranisporites* sp. A | xx |
| *Triletisporites tuberculatus* | xxx |
| *Converrucosisporites* sp. | x |
| *Verrucosisporites* cf. *compactus* | x |
| *Verrucosisporites donarii* | x |
| *Verrucosisporites* cf. *donarii* | xx |
| *Verrucosisporites grandiverrucosus* | xx |
| *Verrucosisporites* cf. *grandiverrucosus* | x |
| *Verrucosisporites microtuberosus* | x |
| *Verrucosisporites sifati* | x |
| *Verrucosisporites* cf. *sinensis* | xx |
| *Verrucosisporites verrucosus* | x |
| *Verrucosisporites* sp. A | x |
| *Kewaneesporites* sp. | x |
| *Lophotriletes gibbosus* | xx |
| *Lophotriletes pseudoaculaetus* | x |
| *Apiculatisporis abditus* | x |
| *Apiculatisporis setulosus* | x |
| *Apiculatisporis variusetosus* | x |

xxx important; xx common; x rare

Table 1 (*continued*)

| | |
|---|---|
| *Acanthotriletes* sp. | x |
| *Apiculatasporites spinulistratus* | xx |
| *Planisporites* spp. | xx |
| *Pustulatisporites crenatus* | x |
| *Tuberculatisporites mamillarius* | x |
| *Raistrickia aculeata* | xx |
| *Raistrickia aculeolata* | xx |
| *Raistrickia* cf. *aculeolata* | xx |
| *Raistrickia crinita* | x |
| *Raistrickia* cf. *crinita* | x |
| *Raistrickia* cf. *crocea* | x |
| *Raistrickia* cf. *dispar* | xx |
| *Raistrickia* cf. *fibrata* | x |
| *Raistrickia lacerata* | xx |
| *Raistrickia* cf. *lacerata* | x |
| *Raistrickia solaris* | x |
| *Raistrickia superba* | xx |
| *Raistrickia* cf. *superba* | x |
| *Raistrickia* sp. A | x |
| *Raistrickia* sp. B | xx |
| ?*Raistrickia* cf. *baculata* | x |
| *Microreticulatisporites nobilis* | xx |
| *Convolutispora* sp. 2 | xx |
| *Convolutispora* sp. B | x |
| *Reticulatisporites lacunosus* | x |
| *Reticulatisporites muricatus* | xx |
| *Savitrisporites maius* | x |
| *Camptotriletes* sp. | x |
| *Dictyotriletes mediareticulatus* | x |
| *Dictyotriletes camptotus* | x |
| *Knoxisporites* sp. | x |
| *Triquitrites bransonii* | xxx |
| *Triquitrites* cf. *bransonii* | xx |
| *Triquitrites bucculentus* | xx |
| *Triquitrites exiguus* | xxx |
| *Triquitrites pulvinatus* | x |
| *Triquitrites verrucosus* | xx |
| *Triquitrites sculptilis* | xx |
| *Firmysporites irregularis* | x |
| *Ahrensisporites* sp. | x |
| *Mooreisporites inusitatus* | x |
| *Mooreisporites* cf. *inusitatus* | xx |
| *Valvisisporites auritus* | xxx |
| *Lycospora brevis* | x |
| *Lycospora denticulata* | x |
| *Lycospora granulata* | xx |
| *Lycospora parva* | xx |
| *Lycospora* cf. *pressoides* | xx |
| *Lycospora pseudoannulata* | xx |
| *Lycospora punctata* | xx |
| *Lycospora pusilla* | xxx |
| *Lycospora subjuga* | xx |
| *Lycospora triangulata* | x |
| *Stenozonotriletes lycosporoides* | x |
| *Crassispora kosankei* | x |
| *Densosporites sphaerotriangularis* | x |
| *Cadiospora magna* | xxx |
| *Cadiospora butterworthi* | x |
| *Gillespieisporites discoideus* | xxx |

Table 1 (*continued*)

| | |
|---|---|
| *Gillespieisporites spinosus* | xxx |
| *Vestispora costata* | xxx |
| *Vestispora fenestrata* | xxx |
| *Vestispora pseudoreticulata* | xx |
| *Vestispora quaesita* | xxx |
| *Vestispora* cf. *profunda* | x |
| *Westphalensisporites irregularis* | x |
| *Bentsisporites tricollinus* | x |
| *Cirratriradites saturni* | xx |
| *Cirratriradites annuliformis* | x |
| *Angulisporites* sp. | x |
| *Triangulatisporites triangulatus* | xxx |
| *Lagenoisporites rugosus* | xx |
| *Cystosporites giganteus* | x |
| *Cystosporites varius* | x |
| *Laevigatosporites desmoinesensis* | xx |
| *Laevigatosporites medius* | x |
| *Laevigatosporites* cf. *medius* | x |
| *Laevigatosporites* sp. C | x |
| *Laevigatosporites* sp. D | x |
| *Laevigatosporites* sp. E | x |
| *Laevigatosporites globosus* | xx |
| *Latosporites* cf. *globosus* | x |
| *Latosporites latus* | x |
| *Punctatosporites minutus* | xx |
| *Punctatosporites oculus* | xxx |
| *Punctatosporites pygmaeus* | xx |
| *Punctatosporites speciosus* | xxx |
| *Spinosporites spinosus* | x |
| *Speciososporites minor* | xxx |
| *Speciososporites infrapunctatus* | xx |
| ?*Speciososporites* cf. *triletoides* | xxx |
| *Endosporites formosus* | xxx |
| *Endosporites* cf. *globiformis* | x |
| *Microsporites gracilis* | x |
| *Wilsonites delicatus* | xx |
| *Wilsonites vesicatus* | x |
| *Latensia triletus* | x |
| *Florinites antiquus* | x |
| *Florinites* cf. *diversiformis* | x |
| *Florinites junior* | x |
| *Florinites mediapudens* | xx |
| *Florinites* cf. *mediapudens* | x |
| *Florinites piérarti* | x |
| *Florinites plicatus* | xx |
| *Florinites pumicosus* | x |
| *Florinites similis* | xx |
| *Florinites visendus* | x |
| *Florinites* cf. *volans* | x |
| *Potonieisporites novicus* | xxx |
| *Potonieisporites novicus* forma *grandis* | xxx |
| *Potonieisporites* cf. *elegans* | xx |
| *Bascanisporites parvisaccus* | x |
| *Candidispora* cf. *candida* | x |
| *Alisporites* sp. A | x |
| *Vesicaspora* sp. A | x |
| *Sulcatisporites* spp. | x |
| *Tumoripollenites* cf. *baccatus* | x |
| *Tumoripollenites* sp. A | xx |

Table 1 (*continued*)

| | |
|---|---|
| *Illinites* sp. A | xx |
| *Striatites* sp. | x |
| ?*Protohaploxypinus* sp. | x |
| *Kosankeisporites elegans* | x |
| ?*Kosankeisporites* sp. A | x |
| *Limitisporites* sp. A | x |
| *Alatisporites* sp. | x |
| *Schopfipollenites ellipsoides* | x |
| ?*Vittatina* sp. | x |

## Comparison

Another coal-bearing succession above the Nýřany Member (Westphalian D) is the Jelenice Member (Stephanian B) with the Mělník Main and Mělník Upper coal seams which were palynologically studied before (1978). The general aspect of the spore assemblages recorded in the Mělník seams appears to be comparable with assemblages found in the Vavřineč group of seams in this area.

The most abundant genera in both cases are *Laevigatosporites* and *Lycospora* but the predominating genus in the Mělník seams is *Laevigatospories* and *Lycospora* in the Nýřany seams. The difference lies in greater percentage of the genera *Cyclogranisporites*, *Verrucosisporites*, *Crassispora* and *Endosporites* in the first case, and *Punctatosporites* and *Triquitrites* in the second one. There are large numbers of spore types occurring in small quantities with no regularity in seams formed during a restricted period. The spores characterizing the assemblages are locally common but never abundant. Typical species that have been recognized only in Mělník seams are *Cyclogranisporites jelenicensis*, *Verrucosisporites sinensis*, *Apiculatisporis conatus*, *Savitrisporites maius*, *Crassispora* spp. (non *C. kosankei*), *Lagenoisporites levis*, *Latosporites melnicensis*, *Speciososporites infrapunctatus*, *Endosporites grandisaccatus* and *Microsporites gracilis*.

Presence in more or less constant but sometimes slightly increased frequency of *Vestispora fenestrata*, *V. costata*, *V. quaesita*, *Cirratriradites saturni*, *Triquitrites bransonii*, *T. exiguus*, *T. sculptilis*, *Punctatosporites minutus* is characteristic of the assemblage of the Nýřany Member.

The Vavřineč group of seams in the Mšeno Basin represents the higher part of the Nýřany Member and is characterized by the following species which have not been recognized in coals in the lower part of this member in other basins: *Laevigatosporites glabratus*, *Triletisporites tuberculatus*, *Raistrickia lacerata*, *Triquitrites verrucosus*, *Firmysporites irregularis*, *Gillespieisporites discoideus*, *G. spinosus*, *Cadiospora magna*, *Punctatosporites speciosus*, *Spinosporites spinosus*, *Speciososporites minor*, *S. infrapunctatus*, *Latensina triletus*, *Candidispora* cf. *candida*, *Potonieisporites novicus* and the genera of disaccate spores.

In the coals in the lower part of the Nýřany Member (developed e.g. in Kladno and Plzeň Basins) has been noted species which has not been found in higher horizons. There were reported the Westphalian C species, and a sharp increase in the number of *Punctatosporites* spp. (mainly *P. microgranifer*) has been observed. *Torispora securis* and *T. laevigata* are regularly distributed throughout the sequence. Many samples yielded specimens of *Reticulatasporites* cf. *facetus*, *Acanthotriletes* sp., *Anapiculatisporites* sp., *Dictyotriletes cingulatus*, *Westphalensisporites irregularis* and two interesting not described types ?*Camptotriletes* and ?*Vallatisporites* sp. A relatively large number of *Tuberculatisporites mamillarius* has been recorded from several horizons.

The palynological data so far accumulated from the upper seams of the Nýřany Member in the Kladno, Plzeň (Chotíkov and Nevřeň group of seams), Manětín and Roudnice Basins and also from the Svatoňovice Member in the Intrasudetic Basin show the same composition and distribution of miofloras as in the Nýřany Member of the Mšeno Basin.

## Palynological zonig

From the palynological viewpoint the Nýřany Member in the Central Bohemian Carboniferous is divided into two palynozones on the basic of megaspore and miospore associations: the lower zone was designated after the megaspore species *Tuberculatisporites mamillarius* and miospore *Torispora securis* as TM-TS, and the upper zone LG-PS after the megaspore species *Laevigatosporites glabratus* and the miospore *Punctatosporites speciosus*. In the Mšeno Basin (the Vavřineč group of seams) just as in the Nýřany Member in the Kladno, Plzeň, Manětín, Roudnice and Intrasudetic Basins the upper palynological zone LG-PS is present. The lower palynological zone TM-TS is known in the Nýřany Member from the Kladno, Plzeň and Manětín Basins as well as from the Carboniferous relics surrounding the Plzeň Basin and from Intrasudetic and Zwickau-Lugau-Oelsnitz (the G.D.R.) Basins.

The miospore associations of the two zones involve a number of genera and species that are also known from other Carboniferous areas of Europe. The Bohemian associations, however, differ from them in lacking miospores of the genus *Thymospora* (except for isolated finds). The zones can be correlated with the zones of the West European and Polish Carboniferous and with the C-VL Zone in the Donec Basin and the W6 Zone of the Dobrudja Basin.

*Přeložila autorka*
*K tisku doporučila N. Gabrielová*

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## Explanation of plates

All photographs by the author

Pl. I

1. *Leiotriletes adnatus*, 2 MB-5/1, CLXIX/34.
2. *L. adnatus*, 2 MB-5/4, CLXX/6.
3. *L. gulaferus*, 9 MB-5/3, 172/23.
4. *L. sphaerotriangulus*, 2 MB-3/2, CLXXV/9.
5. *L. convexus*, 2 MB-7/2, CLXXX/19.
6. *L. gulaferus*, 14-MJ-1/1, CXII/23.
7. *L. gulaferus*, 25 MJ-1/2, CIII/67.
8. *L. adnatoides*, 1 MB-7/5, CLXXXI/29.
9. *L. adnatoides*, 3 MB-3/3, CLXXV/15.
10. *L. tumidus*, 2 MB-7/5, CLXXX/11.
11. *L.* sp., 2 MB-5/1, CLXIX/35.
12. *Punctatisporites bifurcatus*, 25 MJ-1/3, CII/35.
13. *P. bifurcatus*, 1 MB-21/1, CLXXV/20.

14. *P. bifurcatus*, 21 MJ-1/2, C/57.
15. *P.* sp., 12 MB-5/1, CLXXIII/5.
16. *P.* cf. *minutus*, 6 MB-5/1, CLXX1/29.
17. *Calamospora saariana*, 1 MB-3/1, CLXXV/2.
18. *C. saariana*, 1 MB-3/1, CLXXV/2.
19. *C. parva*, 8 MB-5/3, CLXXII/23.
20. *C. microrugosa*, 2 MB-5/4, CLXX/7.
21. *C. microrugosa*, 8 MB-5/3, CLXXII/19.
22. *C. pallida*, 2 MB-5/7, CLXIX/21.
23. *C. pallida*, 12 MB-5/1, 173/5.
24. *C. microrugosa*, 11 MB-5/3, 173/1.

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Pl. II

1. *Calamospora mutabilis*, 3 MB-5/4, CLXX/36.
2. *C. mutabilis*, 2 MB-5/1, CLXIX/36.
3. *C. mutabilis*, 8 MB-5/3, CLXXII/18.
4. *C. mutabilis*, 3 MB-5/3, CLXX/33.
5. *C. mutabilis*, 3 MB-5/1, CLXX/19.
6. *C. mutabilis*, 3 MB-5/3, CLXX/28.
7. *C.* cf. *mutabilis*, 3 MB-3/1, CLXXV/6.
8. *C.* sp., 1 MB-9/4, CLXXIII/15.

×500

Pl. III

1. *Leiotriletes adnatoides*, 8 MJ-7/2, CXXIV/50.
2. *L. tumidus*, 12 MJ-7/1, 126/47.
3. *Cyclogranisporites jelenicensis*, 1 MJ-8/3, CLXXIV/10.
4. ?*C.* sp., 25 MJ-1/4, CIII/33.
5. *Calamospora breviradiata*, 8 MJ-7/2, CXXIIII/1.
6. *C. breviradiata*, 5 MJ-8/4, CLXXIV/33.
7. *Punctatisporites* cf. *punctatus*, 5 MJ-8/4, CLXXIV/35.
8. *Calamospora microrugosa*, 5 MJ-10/2, CXXIX/11.
9. *C.* cf. *breviradiata*, 9 MJ-10/5, CXXX/2.
10. *C. mutabilis*, 2 MJ-7/4, CXXV/6.
11. *Cyclogranisporites* sp. A, 1 MJ-7/2, CXXIV/12.
12. *C.* sp. A, 1 MJ-7/2, CXXIV/18.
13. *Calamospora straminea*, 7 MJ-7/1, CXXX/41.
14. *C. straminea*, 8 MJ-7/3, CXXV/87.
15. *Cyclogranisporites* sp. A, 1 MJ-7/2, CXXIV/22.

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Pl. IV

1. *Variouxisporites* sp., 4 MB-5/3, CLXX1/11.
2. *Granulatisporites parvus*, 2 MB-9/3, CLXXIII/34.
3. *G. parvus*, 1 MB-9/4, CLXXIII/23.
4. *Cyclogranisporites orbicularis*, 1 MB-21/2, CLXXV/30.
5. *C.* sp., 11 Be-1/2, CLX/10.
6. *Granulatisporites* cf. *granulatus*, 9 MB-5/1, CLXXII/26.
7. *Cyclogranisporites orbicularis*, 2 MB-20/3, CLXXV/18.
8. *C. aureus*, 23 Be/6, CLXIX/20.
9. *C.* sp. A, 4 MB-5/1, CLXXI/7.

10. *C. aureus* et *Triquitrites bransonii*, 1 MB-3/4, CLXXV/4.
11. *C. aureus*, 4 MB-5/4, CLXX1/17.
12. *C. aureus*, 4 MB-5/3, CLXX1/13.
13. *C. aureus*, 4 MB-5/3, CLXX1/10.
14. *C. aureus*, 8 MB-5/3, CLXXII/32.
15. *C.* sp., 27 Be-1/1, CLXVI/3.
16. Tetrad of *C.* sp., 12 MB-5/3, CLXXIII/9.

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Pl. V

1. *Cyclogranisporites* sp. A, 1 MJ-7/1, CXXIV/16.
2. *C. aureus*, 11 MJ-7/2, CXXVI/75.
3. *C. aureus*, 12 MJ-7/2, CXXVII/85.
4. *Reticulatasporites* sp., 11 MJ-7/1, CXXVI/49.
5. *Granulatisporites granulatus*, 3 MJ-7/3, CXXV/49.
6. *G. granulatus*, 2 MJ-7/4, CXXV/69.
7. *Lophotriletes* sp., 1 MB-21/2, CLXXV/26.
8. *Cyclogranisporites* cf. *aureus*, 2 MB-7/3, CLXXX/22.
9. *Pustulatisporites crenatus*, 1 MB-3/1, CLXXIV/37.
10. *Lophotriletes gibbosus*, 1 MB-3/1, CLXXV/1.
11. *L. gibbosus*, 2 MJ-7/3, CXXV/71.
12. Tetrad of *Lophotriletes* sp., 2 MB-3/2, CLXXV/12.
13. *L.* sp., 9 MB-5/2, CLXXII/24.
14. *L. pseudoaculeatus*, 3 MB-5/1, CLXX/20.
15. *Verrucosisporites donarii*, 3 MB-5/1, CLXX/80.
16. *V.* cf. *papulosus*, 8 MJ-7/2, CLXXV/17.
17. *V.* cf. *donarii*, 2 MB-7/3, CLXXX/20.
18. *Kewaneesporites* sp., 2 MB-9/2, CLXXIII/26.
19. *Apiculatisporis abditus*, 7 MJ-10/2, CXXX/68.
20. *A.* sp., 12 MJ-7/2, CXXVII/65.
21. *Verrucosisporites microtuberosus*, 30 MJ-1/1, CIV/17.
22. *V. grandiverrucosus*, 3 MB-9/1, CLXXIII/36.
23. *V. verrucosus*, 3 MB-9/1, CLXXIII/39.

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Pl. VI

1. *Granulatisporites* cf. *pannosites*, 8 MB-5/3, CLXXII/22.
2. *Verrucosisporites* sp. A, 3 MJ-8/1, CLXXIV/29.
3. *V.* sp. A, 2 MJ-7/4, CXXV/61.
4. *V.* cf. *donarii*, 8 MJ-10/3, CXXX/46.
5. *V.* sp., 11 MJ-7/2, CXXVI/77.
6. *V.* cf. *grandiverrucosus*, 1 MJ-8/1, CLXXIV/9.
7. *V. microtuberosus*, 11 MJ-7/2, XXXVI/87.
8. *V. grandiverrucosus*, 9 MJ-10/5, CXXX/18.
9. *V. sifati*, 10 MJ-10/3, CXXXI/13.
10. *V.* cf. *sinensis*, 9 MJ-7/2, CXXVI/17.
11. *V.* cf. *sinensis*, 8 MJ-7/2, CXXV/2.
12. *Planisporites* sp., 1 MJ-7/2, CXXIV/88.
13. *P.* sp., 2 MB-3/2, CLXXV/11.
14. *P.* sp. et ?*Converrucosisporites* sp., 1 MB-9/5, CLXXIII/19.
15. *P.* sp., 5 MJ-10/3, CXXX/88.


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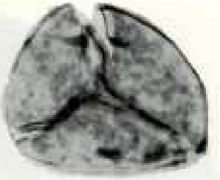
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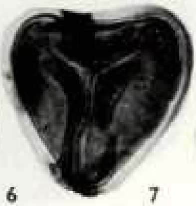
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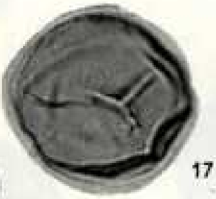
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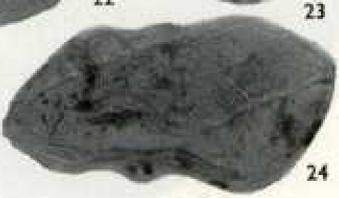
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Pl. II


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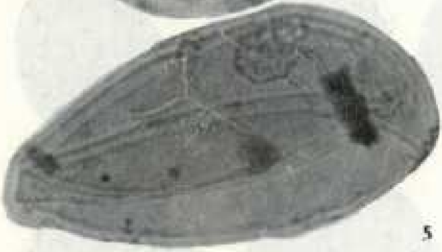
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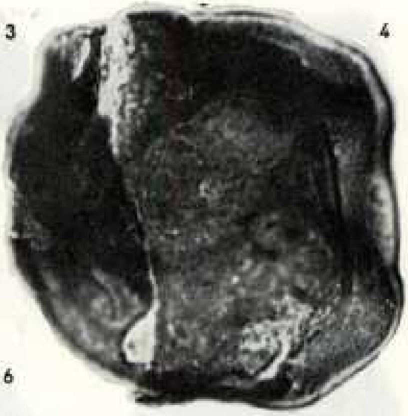
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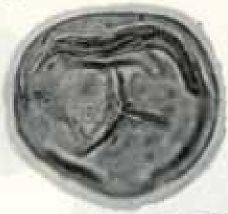
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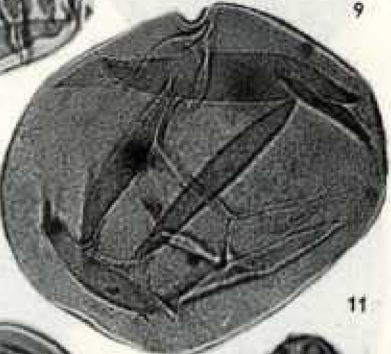
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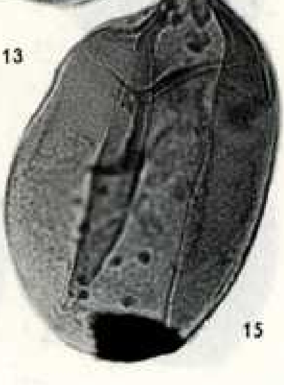
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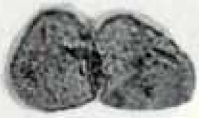
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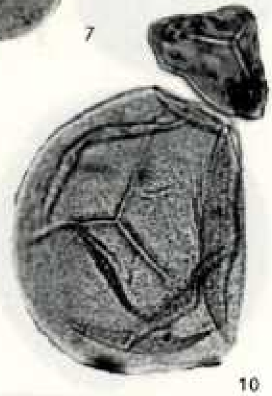
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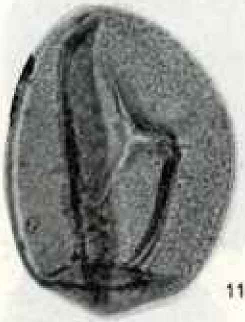
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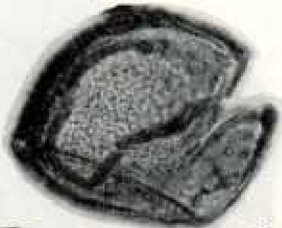
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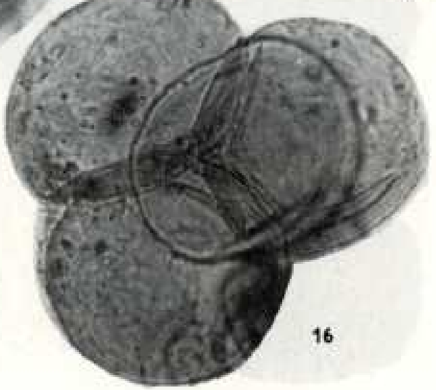
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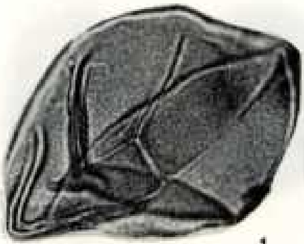
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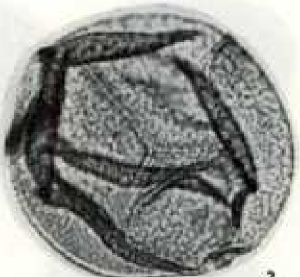
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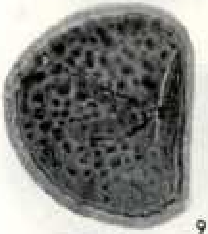
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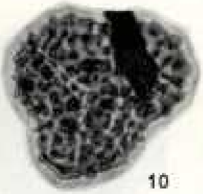
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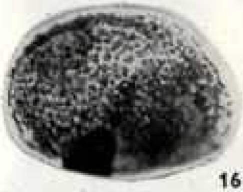
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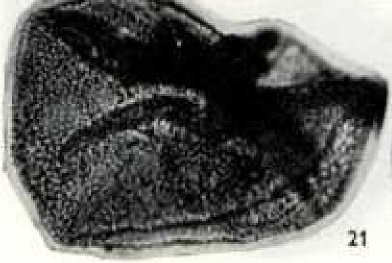
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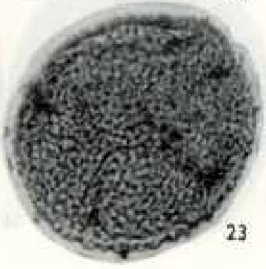
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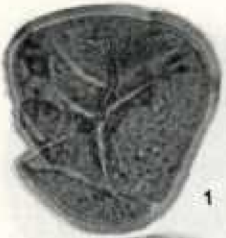
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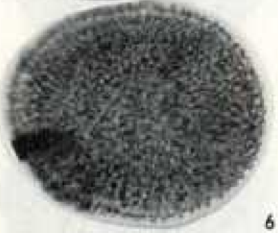
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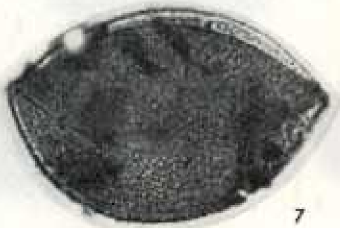
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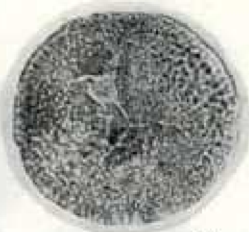
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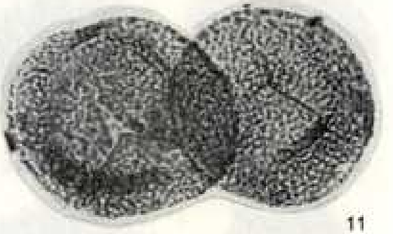
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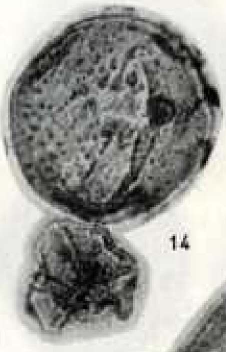
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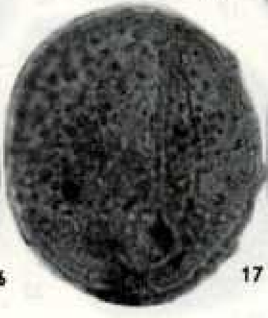
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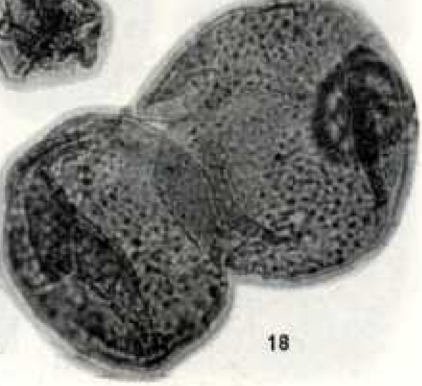
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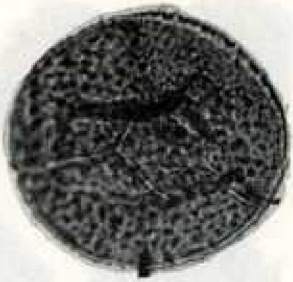
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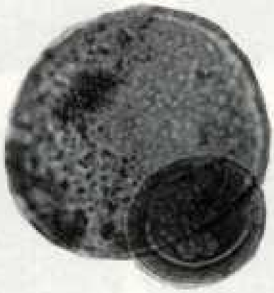
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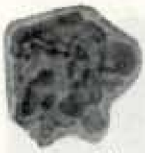
Pl. VIII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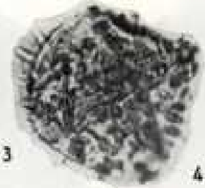
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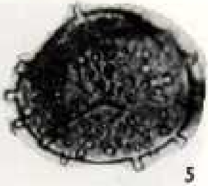
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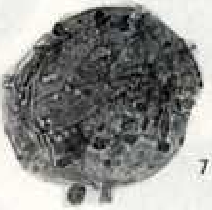
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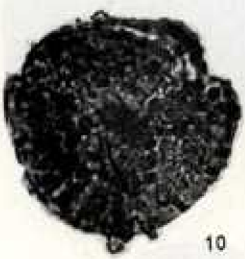
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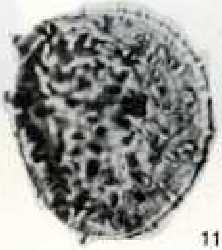
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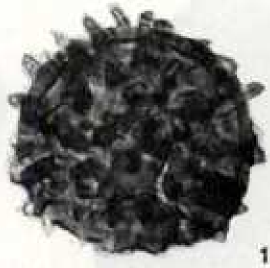
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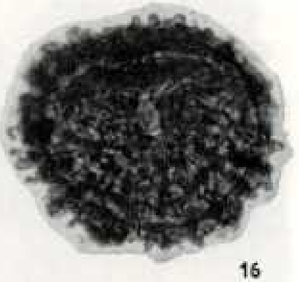
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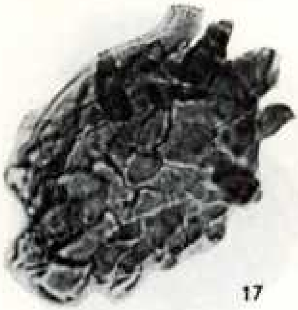
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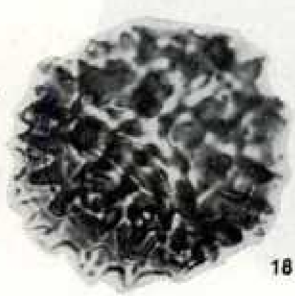
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Pl. IX


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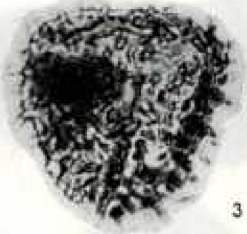
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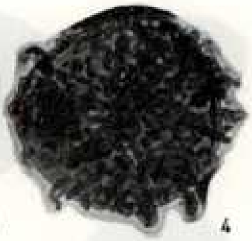
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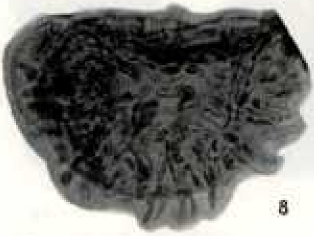
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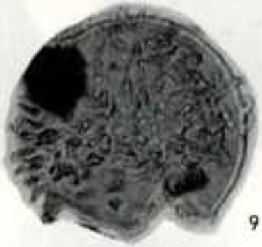
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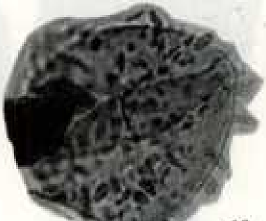
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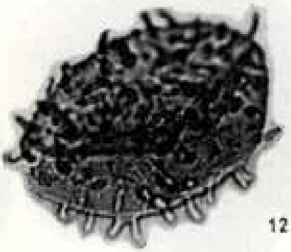
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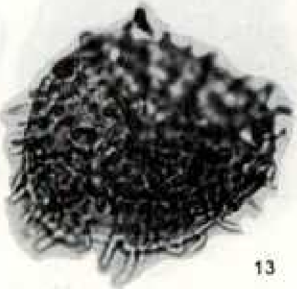
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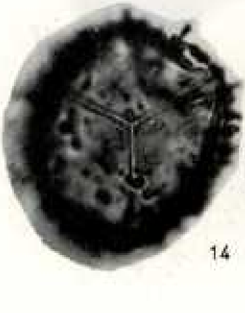
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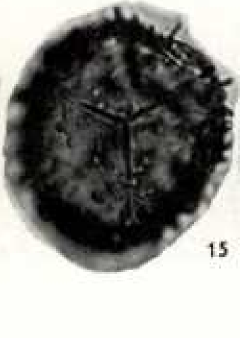
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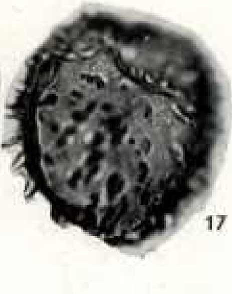
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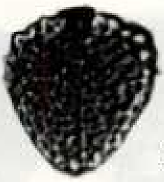
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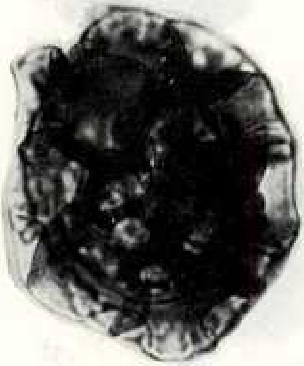
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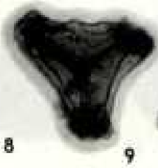
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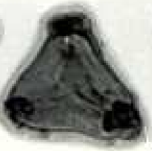
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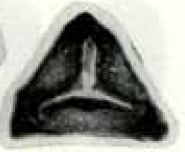
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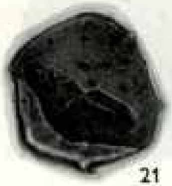
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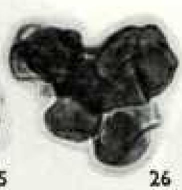
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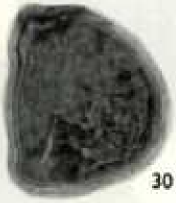
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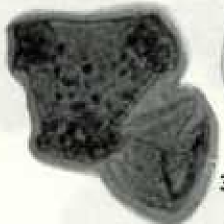
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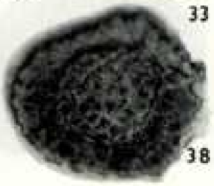
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Pl. XII


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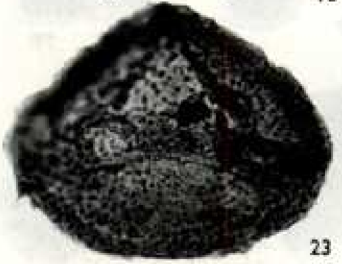
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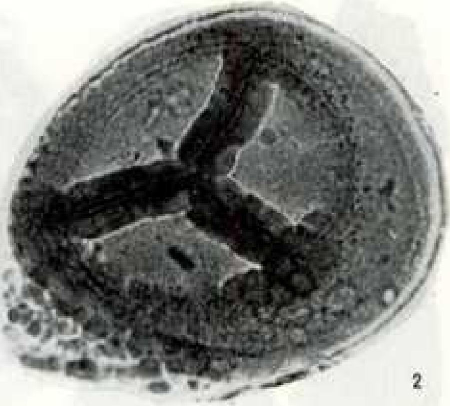

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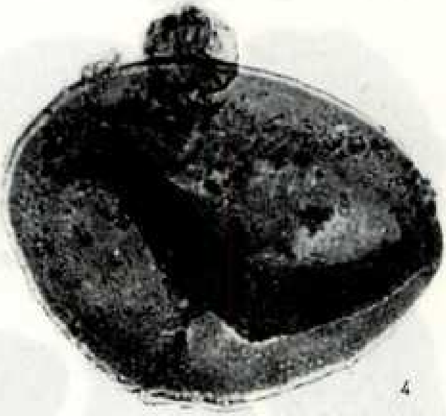

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Pl. XIV


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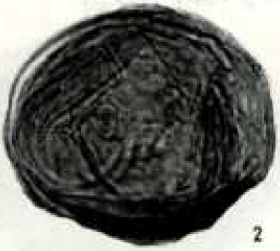
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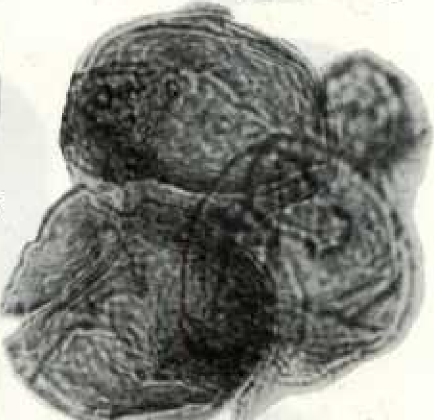
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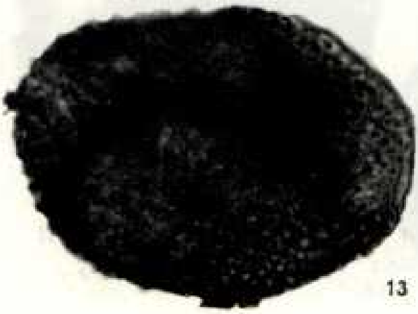
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M. Kalibová: Palynology of the Nýřany Member (Westphalian D) in the Mšeno Basin

Pl. XVII


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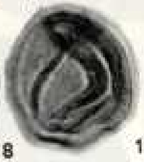
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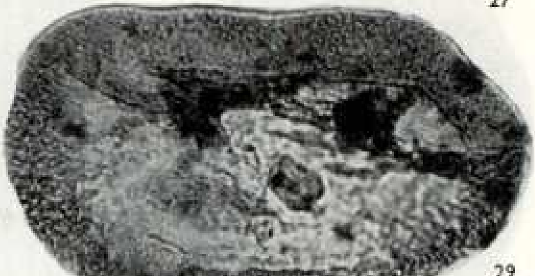
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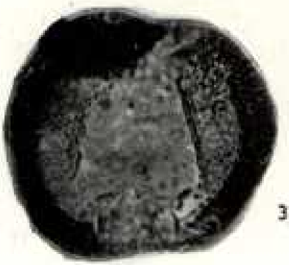
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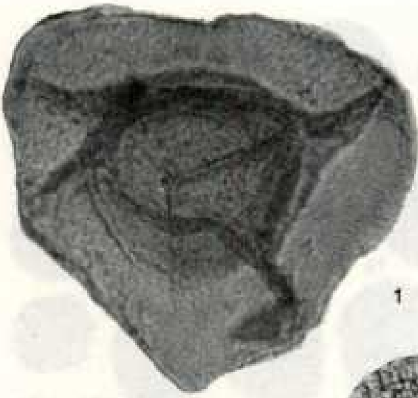
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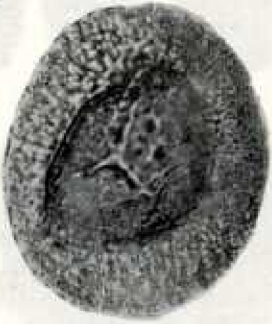
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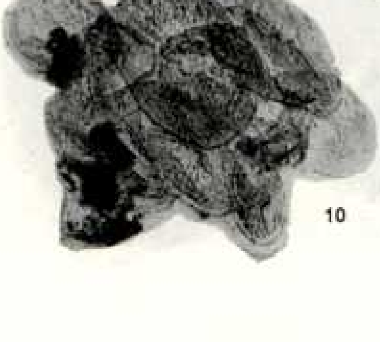

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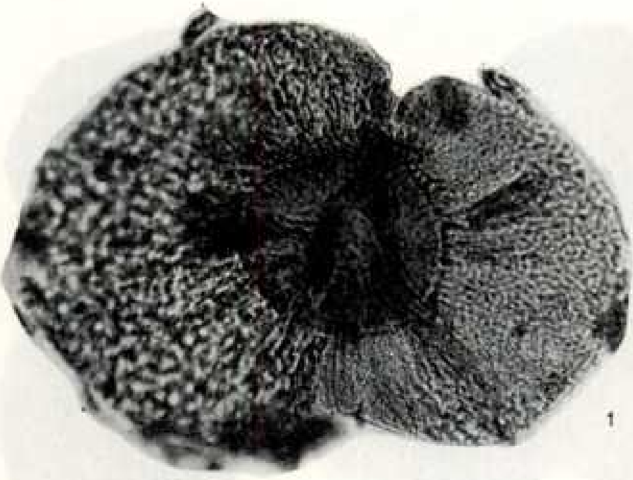
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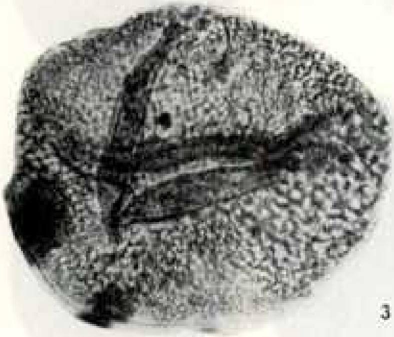
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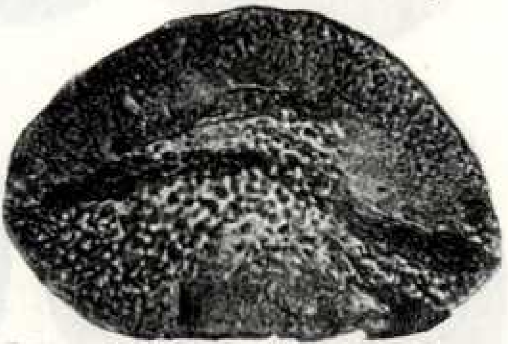
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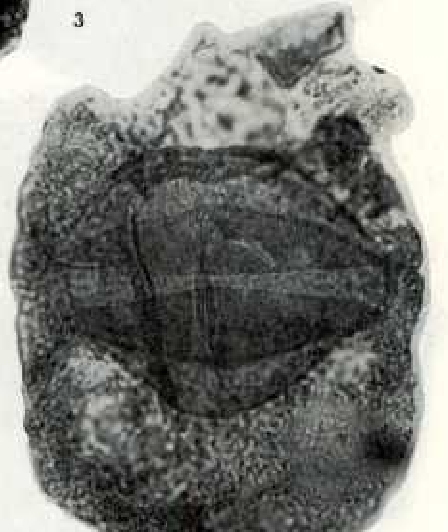
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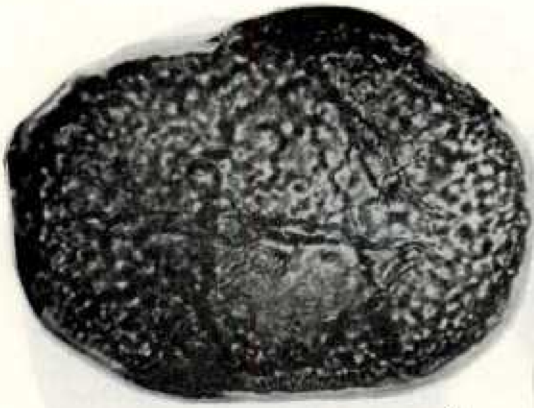

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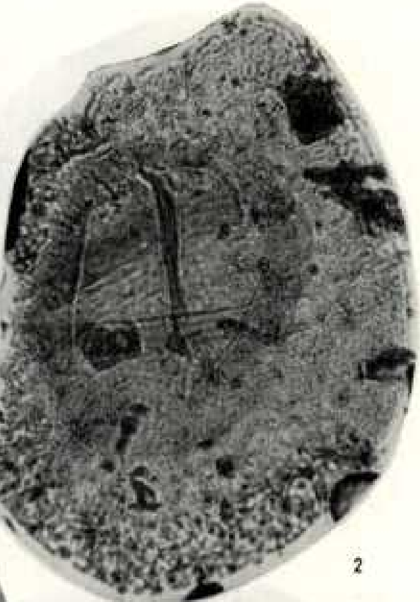

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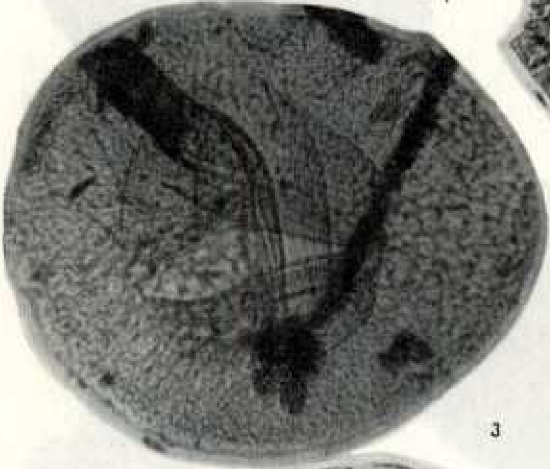

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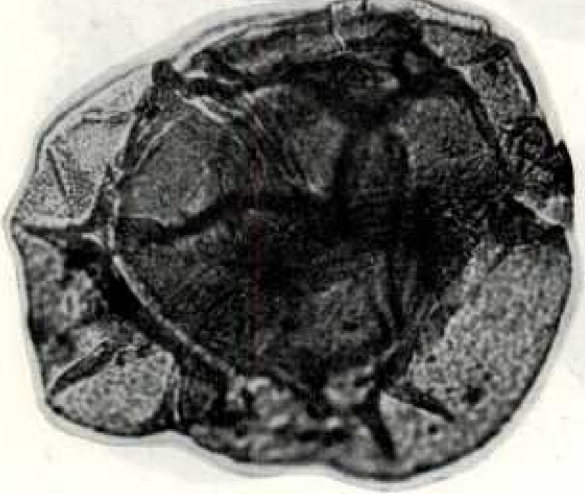

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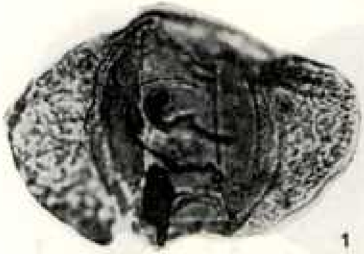

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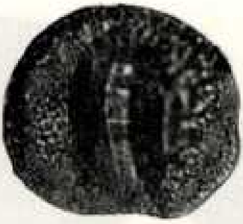

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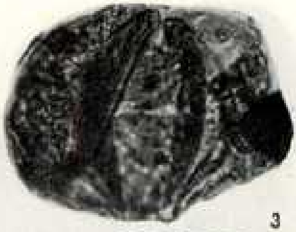

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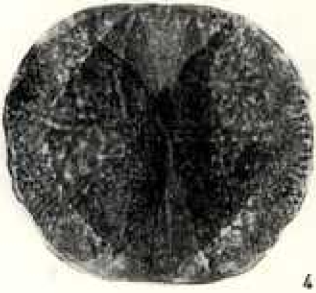

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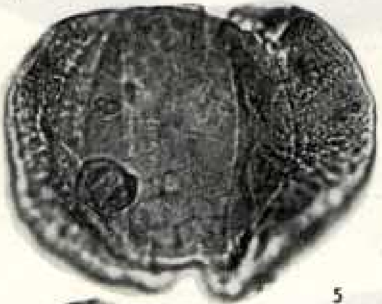

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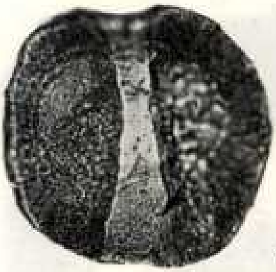

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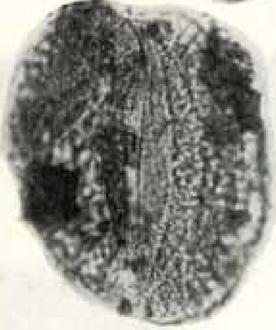

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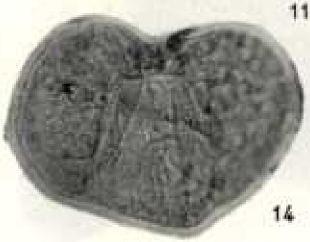

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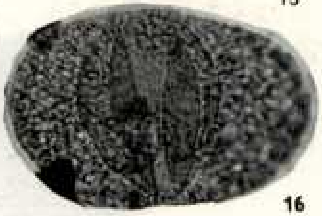
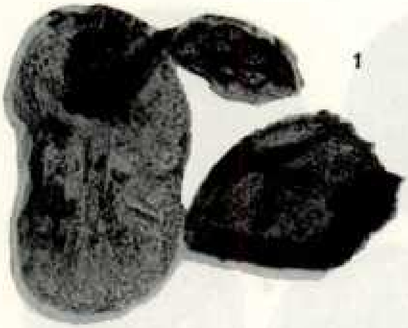


16

Pl. XXIV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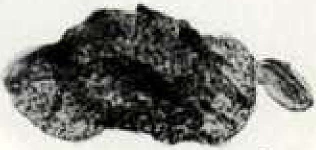
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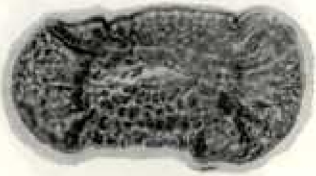
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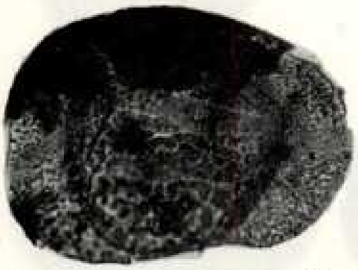
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14


11

16. *Apiculatasporites spinulistratus*, 7 MB-5/1, CLXXI/34.
17. *A. spinulistratus*, 5 MB-5/1, CLXXI/20.
18. *A. spinulistratus*, 5 MJ-8/1, CLXXIV/30.

×500

Pl. VII

1. *Apiculatisporis variusetosus*, 3 MB-9/2, CLXXIII/37.
2. *A. variusetosus*, 8 MB-5/3, CLXXII/17.
3. *A. variusetosus*, 5 MJ-8/1, CLXXIV/37.
4. *Planisporites* sp., 4 MB-9/2, CLXXIV/4.
5. *P.* sp., 4 MB-9/2, CLXXIV/4.
6. *P.* sp., 2 MB-5/2, CLXX/X2.
7. *Gillespieisporites discoideus*, 52 MJ-1, CIX/55.
8. *Microreticulatisporites* sp., 5 MJ-8/1, CLXXIV/32.
9. *Gillespieisporites* sp., 9 MJ-10/5, CXXX/6.

×500

Pl. VIII

1. *Raistrickia* sp., 11 MB-5/2, CLXXII/39.
2. *R. superba*, 7 MJ-10/2, CXXX/58.
3. *R. superba*, 8 MJ-10/2, CXXX/48.
4. *R.* cf. *fibrata*, 8 MJ-7/2, CXXV/29.
5. *R.* cf. *superba*, 1 MB-7/4, CLXXXI/26.
6. *R.* sp. A, 2 MB-7j1, CLXXX/8.
7. *R.* sp. B, 8 MJ-7/3, CXXV/85.
8. *R.* sp. B, 8 MJ-10/2, CXXV/25.
9. *R.* cf. *crinita*, 2 MB-7/2, CLXXX/16.
10. *R. aculeolata*, 8 MJ-10/3, CXXV/89.
11. *R. aculeolata*, 1 MB-7/4, CLXXXI/24.
12. *R.* cf. *lacerata*, 2 MB-5/1, CLXIX/37.
13. *R. lacerata*, 1 MB-3/1, CLXXIV/39.
14. *R.* sp. B, 8 MJ-7/2, CXXV/15.
15. *R.* sp. B, 8 MJ-7/2, CXXV/13.
16. *R.* sp. B, 1 MJ-8/4, CLXXIV/24.
17. *R. lacerata*, 1 MJ-7/1, CXXIV/76.
18. *R.* sp. B, 9 MJ-10/5, CXXX/4.
19. *R. solaris*, 7 MJ-7/2, CXXVI/21.

×500

Pl. IX

1. *Raistrickia aculeolata*, 7 MB-5/1, 1LXXI/37.
2. *R. aculeolata*, 8 MB-5/1, CLXXII/13.
3. *R. aculeolata*, 1 MB-7/4, CLXXXI/27.
4. *R. aculeolata*, 1 MJ-8/1, CLXXIV/10.
5. *R. aculeolata*, 1 MB-7/1, CLXXV/27.
6. ?*R.* cf. *baculata*, 2 MJ-7/4, CXXV/5.
7. *R.* cf. *dispar*, 1 MB-21/2, CLXXV/37.
8. *R. crinita*, 7 MB-5/1, CLXXII/5.
9. *R.* cf. *dispar*, 12 MB-5/3, CLXXIII/10.
10. *R.* cf. *dispar*, 7 MB-5/1, CLXXII/3.
11. *R.* cf. *crocea*, 2 MB-7/3, CLXXX/21.
12. *R. aculeata*, 8 MJ-10/1, CXXIX/13.

13. *R. aculeata*, 8 MJ-7/3, CXXX/31.
14. *R.* cf. *aculeolata*, 7 MB-25, CCXXIV/62.
15. *R.* cf. *aculeolata*, at higher focus, 7 MB-25, CCXXIV/63.
16. *R.* cf. *aculeolata*, at higher focus, 7 MB-25, CCXXIV/64.
17. *R.* cf. *aculeolata*, at higher focus, 7 MB-25, CCXXIV/65.

×500

Pl. X

1. *Microreticulatisporites nobilis*, 3 MB-3/3, CLXXV/16.
2. *M. nobilis*, 8 MJ-7/1, CXXIV/40.
3. *M. nobilis*, 12 MJ-7/2.
4. *M. nobilis*, 11 MJ-7/3, CXXVI/65.
5. *Convolutispora* sp. 2 Peppers, 2 MJ-8/2, CLXXIV/28.
6. *C.* sp. B, 5 MB-5/5, CLXXI/25.
7. *C.* sp. B, 5 MB-5/5, CLXXI/26.
8. *C.* sp., 3 MB-5/1, CLXX/18.
9. *C.* sp., 3 MB-5/2, CLXX/22.
10. Undetermined spore, 3 MB-5/1, CLXX/17.
11. *Dictyotriletes mediareticulatus*, 1 MB-6/2, CLXXIV/7.
12. *Savitrisporites maius*, 2 MB-3/2, CLXXV/10.
13. *Microreticulatisporites* sp., 2 MB-5/3, CLXX/3.
14. *Verrucosisporites* cf. *compactus*, 9 MJ-10/1, CXXX/28.
15. *Reticulatiosporites lacunosus*, 3 MJ-10/5, CXXIX/33.
16. *R. lacunosus*, 2 MB-3/1, CLXXV/7.
17. *R. muricatus*, 3 MJ-10/3, CXXIX/51.

×500

Pl. XI

1. *Triquitrites bucculentus*, 9 MB-5/3, CLXXII/31.
2. *T. bucculentus*, 9 MB-5/3, CLXXII/39.
3. *T. bucculentus*, 2 MB-5/4, CLXIX/9.
4. *T. exiguus*, 12 MB-5/4, CLXX/11.
5. *T. exiguus*, 11 MJ-7/2, CXXVI/85.
6. *T. exiguus*, 1 MB-7/5, CLXXX/30.
7. *T. bransonii*, 7 MJ-7/1, CXXV/43.
8. *T. bransonii*, 3 MJ-1/L, CXII/33.
9. *T. bransonii*, 3 MB-3/1, CLXXV/13.
10. *T. bransonii*, 1 MB-9/4, CLXXIII/20.
11. *T. bransonii*, 2 MB-7/2, CLXXX/17.
12. *T.* sp., 2 MB-7/2, CLXXX/15.
13. *T.* cf. *bransonii*, 12 MJ-7/2, CXXVII/77.
14. *T.* cf. *bransonii*, 1 MJ-7/2, CXXIV/90.
15. *T.* cf. *bransonii*, 1 MJ-7/2, CXXIV/2.
16. *T.* cf. *bransonii*, 12 MJ-7/2, CXXVII/65.
17. *T.* cf. *bransonii*, 12 MJ-7/1, CXXVI/51.
18. *T.* cf. *bransonii*, 2 MB-7/2, CLXXX/9.
19. *T.* sp., 11 MB-5/4, CLXXIII/4.
20. *Gillespieisporites* sp., 1 MJ-7/1, CXXIV/20.
21. *G.* sp., 1 MJ-7/2, CXXIV/8.
22. *T.* cf. *subspinosus*, 9 MB-5/3, CLXXIII/32.
23. *T. pulvinatus*, 1 MB-3/1, CLXXV/3.

24. *T.* sp. A, 11 MB/5/4, CLXXIII/4.
25. *T.* sp. A, 1 MJ-7/1, CXXIV/20.
26. *Firmysporites irregularis*, 1 MJ-7/2, CXXIV/8.
27. *F. irregularis*, 9 MB-5/3, CLXXII/32.
28. *Triquitrites* sp., 1 MB-3/1, CLXXV/3.
29. *Gillespieisporites spinosus*, 12 MJ-7/3, CXXVII/57.
30. *G. spinosus*, 1 MB-7/1, CLXXXI/23.
31. *Triquitrites verrucosus* et *Lycospora* sp., 1 MJ-7/2, CXXIV/6.
32. *T. verrucosus*, 1 MJ-7/2, CXXIV/4.
33. *T. verrucosus*, 12 MJ-7/1, CXXVI/45.
34. *Ahrensisporites* sp., 8 MJ-10/2, CXXX/54.
35. *Westphalensisporites irregularis*, 5 MB-5/4, CLXXI/27.
36. ?*Ahrensisporites* sp., 4 MB-5/1, CLXX/38.
37. ?*Firmysporites* sp., 8 MJ-10/3, CXXX/44.
38. *Densosporites sphaerotriangularis*, 8 MB-5/2, CLXXII/14.

×500

Pl. XII

1. *Lycospora pseudoannulata*, 12 MJ-7/1, CXXVI/59.
2. *L. pseudoannulata*, 12 MJ-7/2, CXXVII/89.
3. *L. punctata*, 8 MJ-7/2, CXXIV/54.
4. *L. punctata*, 11 MJ-7/3, CXXVI/73.
5. *L. punctata*, 8 MJ-7/1, CXXIV/48.
6. *L. brevijuga*, 11 MJ-7/2, CXXVI/89.
7. *L. brevijuga*, 12 MJ-7/1, CXXVI/41.
8. *L. pusilla*, 12 MJ-7/1, CXXVI/33.
9. *L. brevijuga*, 3 MJ-7/1, CXXV/59.
10. *L. brevijuga*, 2 MJ-7/2, CXXV/79.
11. *L. pusilla*, 8 MJ-7/2, CXXIV/44.
12. *L. pusilla*, 11 MJ-7/3, CXXVI/67.
13. *L.* sp., 3 MJ-7/1, CXXV/55.
14. *L.* sp., 11 MJ-7/2, CXXVI/81.
15. *Stenozonotriletes lycosporoides*, 12 MJ-7/1, CXXVI/43.
16. *L. parva*, 11 MJ-7/1, CXXVI/3.
17. *L. parva*, 2 MJ-7/1, CXXIV/68.
18. *L. parva*, 11 MJ-7/3, CXXVI/71.
19. *L. subjuga*, 2 MJ-7/1, CXXIV/66.
20. *L. subjuga*, 11 MJ-7/3, CXXVI/69.
21. *L.* cf. *pressoides*, 2 MJ-7/2, CXXVI/75.
22. *L.* cf. *pressoides*, 12 MJ-7/1, CXXVI/53.
23. *Crassispora kosankei*, 18 MJ-1/2, CXII/9.
24. *Vestispora quaesita*, 2 MB-7/2, CLXXX/14.
25. *V. quaesita*, 1 MB-6/1, CLXXIV/5.
26. *V. quaesita*, 12 MJ-7/3, CXXVII/59.
27. *Cadiospora magna* f. *maior*, 2 MJ-8/4, CLXXIV/26.
28. *C. butterworthi*, 25 MJ-2/3, CII/57.
29. Undetermined spore, 12 MB-5/3, CLXXIII/8.
30. *Vestispora fenestrata*, 6 MJ-10/1, CXXX/74.
31. Underermined spore, 1 MB-20/1, CLXXV/17.
32. ?*Cadiospora* sp., 6 MJ-7/3, CXXV/3.

×500

Pl. XIII

1. *Cadiospora magna* f. *maior*, 4 MB-21/1, CLXXV/39
2. *C. magna* f. *maior*, 4 MB-21/1, CLXXV/38.
3. *C. magna* f. *maior*, 1 MJ-8/4, CLXXIV/21.
4. *C. magna* f. *maior*, 1 MB-7/4, CLXXXI/25.
5. *C. magna* f. *maior*, 10 MJ-10/1, CXXX/22.
6. *C. magna* f. *maior*, 1 MJ-8/1, CLXXIV/11.

× 500

Pl. XIV

1. *Gillespieisporites spinosus*, 1 MJ-7/3, CXXIV/82.
2. *G. spinosus*, 1 MJ-7/3, CXXIV/86.
3. *G. spinosus*, 7 MJ-7/1, CXXV/37.
4. *G. spinosus*, 1 MJ-7/3, CXXIV/80.
5. *G. discoideus*, *Endosporites formosus* et *Punctatosporites* sp., 50 MJ-1/1, CVIII/49.
6. *G.* sp. forma *gulaferus*, 9 MB-5/2, CLXXII/25.
7. *G. discoideus*, 11 MB-5/2, CLXXII/3.
8. *G. discoideus*, 5 MB-5/1, CLXXI/19.
9. *G. discoideus*, 2 MB-3/2, CLXXV/8.
10. *G. discoideus*, 1 MJ-7/2, CXXIV/7.
11. *G. discoideus*, 7 MB-5/5, CLXXII/7.
12. *G. discoideus*, 7 MB-5/1, CLXXII/6.
13. *G. spinosus*, 6 MB-5/2, CLXXI/31.
14. *G. spinosus*, 8 MJ-10/2, CXXX/5.
15. *G. spinosus*, 1 MJ-7/3, CXXIV/78.
16. *Mooreisporites* cf. *inusitatus*, 2 MB-5/4, CLXX/10.
17. *M.* cf. *inusitatus*, 3 MB-5/2, CLXX/23.
18. *M.* cf. *inusitatus*, 7 MB-5/1, CLXXIXXI/33.
19. *M. inusitatus*, 7 MB-5/1, CLXXI/XXXIII.

× 500

Pl. XV

1. *Vestispora costata*, 9 MJ-10/4, CXXX/8.
2. *V. costata*, 8 MJ-7/4, CXXV/9.
3. *V. costata*, 5 MJ-10/4, CXXX/86.
4. *V. costata*, 3 MB-5/3, CLXX/29.
5. *V. costata*, 8 MB-5/3, CLXXII/20.
6. *V. costata*, 2 MB-9/2, CLXXIII/27.
7. *V. costata*, 11 MJ-7/1, CXXVI/5.
8. *V. costata*, 1 MB-9/4, XCLXXIII/16.
9. *V.* cf. *profunda*, 2 MJ-7/1, CXXIV/65.
10. *V.* cf. *profunda*, 11 MJ-7/1, CXXVI/7.
11. *V.* cf. *profunda*, 4 MB-5/1, CLXXI/5.
12. Undetermined spore, 1 MB-9/2, CLXXIII/13.
13. *V. fenestrata*, 16 MJ-10/1, CXXX/74.
14. *V. fenestrata*, 7 MB-5/1, CLXXII/1.
15. *V. costata*, 9 MB-9/2, CLXXIII/29; magnification 250 ×.

× 500 unless otherwise stated.

Pl. XVI

1. *Angulisporites* sp., 8 MJ-7/3, CXXV/83.
2. *Cirratriradites saturni*, 7 MJ-7/1, CXXVI/23.

3. *C. saturni*, MJ-1 (600. 60—600.90 m)5, CXII/64.
4. *C. saturni*, 8 MJ-7/4, CXXV/5; high focus.
5. *C. saturni*, 8 MJ-7/4, CXXV/7; same specimen shown in figure 4 but low focus.
6. *Cadiospora magna* f. *minor*, 8 MJ-7/2, CXXIV/39 .
7. *Cirratriradites annuliformis*, 2 MB-7/2, CLXXX/12.
8. *C. annuliformis*, 25 MJ-1/3, CII/4.
9. ?*Punctatosporites* sp., MJ-1(600.60—600.90 m)5, CXI/72; high focus.
10. ?*Punctatosporites* sp., MJ-1(600.60—600.90 m)5, CXI/70; same specimen shown in figure 4 but low focus.
11. *Schopfipollenites ellipsoides*, 2 MJ-1/1, IC/43; magnification 250×.

×500 unless otherwise stated.

Pl. XVII

1. *Laevigatosporites* sp. C, 1 MJ-7/3, CXXIV/84.
2. *L.* sp. D, 3 MJ-7/3, CXXV/51.
3. *Punctatosporites speciosus*, 1 MJ-7/1, CXXIV/14.
4. *P. speciosus*, 11 MJ-7/2, CXXVI/1.
5. *P. speciosus*, 2 MB-7/2, CLXXX/19.
6. *P. speciosus*, 12 MJ-7/1, CXXVI/37.
7. *P. speciosus*, 7 MJ-7/2, CXXVI/19.
8. *P. pygmaeus*, 1 MJ-7/2, CXXIV/10.
9. *P. pygmaeus*, 8 MJ-7/1, CXXIV/52.
10. *Speciososporites minor*, 2 MB-7/2, CLXXX/3.
11. *S. minor*, 1 MB-6/4, CLXXIV/8.
12. *S. minor*, 12 MJ-7/1, CXXVI/55.
13. *S. minor*, 11 MJ-7/3, CXXVI/63.
14. *S. minor*, 7 MJ-7/1, CXXV/39.
15. *S. minor*, 12 MJ-7/1, CXXVI/39.
16. *S. minor*, 8 MJ-7/1, CXXIV/52.
17. *S. minor*, 2 MJ-7/3, CXXV/73.
18. ?*S.* cf. *triletoides*, MJ-10/2, CXXX/64.
19. *S. infrapunctatus*, 7 MJ-7/1, CXXV/45.
20. *S. infrapunctatus*, 11 MB-5/4, CXXIIII/2.
21. *Spinosporites spinosus*, 2 MB-21/2, CLXXV/34.
22. *S.* sp., 7 MJ-10/2, CXXX/66.
23. *Latosporites* cf. *globosus*, 8 MJ-7/1, CXXIV/56.
24. Undetermined, 7 MB-5/5, CLXXII/8.
25. *Hymenospora* sp., 3 MB-5/4, CLXX/35.
26. *H. paucirugosa*, 1 MB-21/2, CLXXV/24.
27. *H.* sp. A, 1 MB-3/4, CLXXV/5.
28. *Latensina* sp., 2 MB-9/2, CLXXIII/31.
29. *L.* sp., 1 MB-21/2, CLXXV/29.
30. *Sulcatisporites* sp., 1 MB-21/1, CLXXV/22.
31. *Latensina* sp., 1 MJ-7/1, CXXV/47.
32. *L.* sp., 1 MJ-8/4, CLXXIV/19.

×500

Pl. XVIII

1. *Endosporites formosus*, 1 MB-9/2, CLXXIII/12.
2. *E. formosus*, 9 MJ-7/3, CXXVI/9.
3. *Wilsonites vesicatus*, 12 MJ-7/2, CXXVII/79.

4. *W. delicatus*, 12 MJ-7/2, CXXVII/79.
5. *W.* sp., 1 MB-21/2, CLXXV/32.
6. Undetermined spore, 4 MB-21/1, CLXXV/36.
7. *Endosporites* cf. *globiformis*, 8 MJ-7/1, CXXIV/46.
8. *Wilsonites delicatus*, 8 MJ-8/4, CLXXIV/25.
9. *W.* sp., 2 MB-7/2, CLXXX/10.
10. *Endosporites* sp., 12 MB-5/1, CLXXIII/7.
11. *Wilsonites* sp., 1 MJ-8/3, CLXXIV/14.

×500

Pl. XIX

1. *Potonieisporites* sp. et *Florinites* sp., 1 MB-21/3, CLXXV/33.
2. *Candidispora* cf. *candida*, 7 MJ-10/2, CXXX/56.
3. *C.* sp., 2 MB-9/4, CLXXIII/35.
4. *Florinites similis*, 9 MJ-7/1, CXXVI/13.
5. *F. plicatus*, 9 MJ-7/3, CXXVI/11.
6. *F. plicatus*, 12 MJ-7/1, CXXVII/57.
7. *F. plicatus*, 2 MJ-7/2, CXXV/77.
8. *F. piérarti*, 2 MB-5/1, CLXIX/32.
9. *F. antiquus*, 9 MJ-10/1, CXXX/30.
10. *F.* sp., 1 MJ-8/4, CLXXIV/20; magnification 250×.
11. *F.* sp., 1 MB-9/4, CLXXIII/17.
12. *F.* cf. *mediapudens*, 2 MJ-10/2, CLXXIX/55.

×500 unless otherwise stated.

Pl. XX

1. *Florinites* cf. *diversiformis*, 1 MB-9/4, CLXXIII/22.
2. *F.* sp., 1 MJ-8/4, CLXXIV/18.
3. *F. plicatus*, 1 MB-21/3, CLXXV/33.
4. Undetermined spore, 6 MJ-10/0, CXXV/81.
5. *Potonieisporites* sp. et undetermined saccate spore, 1 MJ-8/3, CLXXIV/13.

×500

Pl. XXI

1. *Potonieisporites* sp., 1 MB-6/2, CLXXIV/6.
2. *P. novicus* forma *grandis*, 2 MJ-7/2, CXXV/67.
3. *P. novicus*, 2 MB-20/2, CLXXV/19.
4. Tetrad of *Florinites mediapudens*, 2 MD-9/3, CLXXIII/33.
5. *Potonieisporites novicus* forma *grandis*, 12 MJ-7/2, CXXVII/75.

×500

Pl. XXII

1. *Potonieisporites novicus*, 2 MJ-1/1, IC/47.
2. *P. novicus* forma *grandis*, 3 MB-9/4, CLXXIII/40.
3. *P. novicus* forma *grandis*, 1 MB-9/5, CLXXIII/18.
4. *Limitisporites* sp., 4 MB-9/1, CLXXIV/2.
5. Undetermined saccate spore, 9 MJ-7/1, CXXVI/15.
6. *Limitisporites* sp., 3 MJ-10/3, CXXIX/45.

×500

Pl. XXIII

1. *Kosankeisporites* sp. A, 8 MJ-7/2, CXXV/19.
2. *Limitisporites* sp. A, 9 MJ-10/3, CXXIX/43.

3. *L.* sp. A, 1 MB-21/1, CLXXV/21.
4. *L.* sp., 3 MJ-10/3, CXXIX/47.
5. *Kosankeisporites* sp. A, 8 MJ-10/5, CXXX/38.
6. *Alisporites* sp. A, 3 MJ-10/1, CXXIX/37.
7. *A.* sp. A, 12 MJ-7/2, CXXVII/1.
8. *Vesicaspora* sp. A, 7 MJ-10/2, CXXX/60.
9. ?*Kosankeisporites* sp., 1 MB-9/1, CLXXIII/11.
10. *Vesicaspora* sp. A, 1 MB-9/4, CLXXIII/21.
11. *Illinites* sp. A, 3 MJ-10/4, CXXV/39.
12. *I.* sp. A, 4 MB-9/1, CLXXIV/1.
13. *I.* sp. A, 4 MB-5/1, CLXX/39.
14. *I.* sp. A, 2 MB-5/5, CLXX/16.
15. *I.* sp. A, 3 MB-5/3, CLXX/32.
16. *I.* sp. A, 1 MJ-8, CLXXIV/22.

×500

Pl. XXIV

1. Undetermined spores, 1 MJ-8/4, CLXXIV/23; ×250.
2. ?*Potonieisporites* sp., 12 MJ-7/2, CXXVII/81.
3. *Wilsonites* sp., 1 MJ-8/3, CLXXIV/15.
4. *Tumoripollenites* sp. A, 12 MJ-7/2, CXXVII/65.
5. *T.* sp. A, 11 MJ-7/2, CXXVI/73.
6. *T.* cf. *baccatus*, 1 MB-21/2, CLXXV/23.
7. *Vittatina* sp., 12 MJ-7/1, CXXVI/31.
8. Undetermined disaccate spore, 1 MB-21/2, CLXXV/25.
9. *Tumoripollenites* sp. A, 5 MB-5/4, CLXXI/28.
10. ?*Kosankeisporites* sp. A, 11 MJ-7/2, CXXVI/83.
11. ?*Protohaploxypinus* sp., 3 MJ-10/1, CXXX/57.
12. Undetermined monosaccate spore, 2 MB-9/2, CLXXIII/30.
13. *Punctatisporites* sp. et *Sporonites* sp., 9 MB-5/1, CLXXII/27.
14. *Variouxisporites* sp., 1 MB-7/4, CLXXXI/28.

×500 unless otherwise stated.

# Palynologie nýřanských vrstev mšenské pánve (vestfál D)

(*Résumé anglického textu*)

MILADA KALIBOVÁ

Předloženo 9. dubna 1985

V předložené práci jsou systematicky zpracovány disperzní spory z uhelných slojí nýřanských vrstev mšenské pánve, které jsou nazývány vavřinečské sousloji (1982). Byly získány z materiálu vrtů provedených Ústředním ústavem geologickým. Jde vesměs o známé rody a druhy miospor a megaspor, příp. o druhy s nimi srovnatelné, a o 11 dalších druhů miospor, které byly nově popsány, ale nepojmenovány. Botanická příbuznost je uvedena jen u těch rodů, které nebyly zastoupeny v mělnických slojích jelenických vrstev mšenské pánve (KALIBOVÁ 1978).

Pokud jde o kvantitativní zastoupení miospor, dominuje v nich rod *Lycospora* se 44 procenty. Hojně se uplatňují rody *Laevigatosporites* a *Punctatosporites*, které oba dosahují v průměru 11,9 procent. Významné zastoupení mají i rody *Calamospora* (5,5 %) a *Triquitrites* (5,7 %). V některých polohách ve slojích dochází k nahromadění megaspor druhu *Valvisisporites auritus* a miospor druhu *Endosporites formosus*. K dalším běžně se vyskytujícím rodům patří *Vestispora* s druhy *V. costata*, *V. fenestrata* a *V. quaesita* (3 %). Druh *Cirratriradites saturni* jen zřídka přesahuje jedno procento, často i chybí. Jen v některých polohách rod *Puctatisporites* dosahuje tří a *Florinites* sedmi procent. Disakátní spory jsou běžné v nejvyšších slojích.

Z megaspor je nejrozšířenějším druhem *Lagenoisporites rugosus* a místy i *Triangulatisporites triangulatus*, běžnými druhy jsou i *Calamospora* sp. a *Cystosporites giganteus*. Omezené zastoupení, avšak stratigrafický význam mají druhy *Laevigatisporites glabratus* a *Triletisporites tuberculatus*.

Miospory druhů *Torispora securis* a *Thymospora* spp., jakož i megaspora druhu *Tuberculatisporites mamillarius*, typická pro spodnější sousloji našeho vestfálu D, se ve slojích mšenské pánve vůbec nevyskytují.

Uhelné sloje v mšenské pánvi mají značně vysokou pozici v nýřanských vrstvách. Obdobné postavení v nich mají i příslušná sousloji v pánvích kladenské, plzeňské, manětínské i roudnické. Jsou s nimi palynologicky dobře korelovatelné také uhelné sloje ve svrchních svatoňovických vrstvách v pánvi vnitrosudetské.

Vavřinečské sousloji náleží z hlediska palynologického zónování do svrchní zóny, kterou označujeme LG-PS podle megasporového druhu *Laevigatisporites glabratus* a miosporového druhu *Punctatosporites speciosus*, který je společně s dalšími druhy tohoto rodu a hlavně pak přechodnými formami k rodům *Cyclogranisporites* a *Speciososporites* pro svrchní zónu typický.

## Палинология ныржанских слоев (вестфал D) Мшенского бассейна

Ныржанские слои, угленосная единица нижней серой свиты каменноугольных отложений в средней Чехии, изучались палинологически в Мшенском бассейне. В угольных пластах, называемых здесь вавржинечской свитой пластов, установлено и изучено палинологически богатое сообщество миоспор и мегаспор. Описано, однако, таксономически не названо, 11 вероятно новых видов миоспор, остальные из установленных относятся к описанным уже раньше видам или же с ними сопоставляются.

*Přeložil A. Kříž*

| Sbor.<br>geol. věd | Paleontologie<br>30 | Pages<br>123—158 | 14<br>figs. | 3<br>tabs. | 12<br>pls. | Praha 1989<br>ISSN 0036-5297 |
|---|---|---|---|---|---|---|

# Stephanian and Permian species of Alethopteris from Bohemia and Moravia

## Alethopteridy stefanu a permu Čech a Moravy

Zbyněk Šimůnek[1]

Received June 30, 1986

Šimůnek Z. (1989): Stephanian and Permian species of *Alethopteris* from Bohemia and Moravia. — Sbor. geol. Věd, Paleont., 30, 123—158. Praha.

Abstract: Revision of Bohemian and Moravian findings exhibited a presence of four species of the genus *Alethopteris* Sternberg: *Alethopteris bohemica* Franke, *Alethopteris moravica* Augusta, *Alethopteris schneideri* (Sterzel) Sterzel and *Alethopteris zeilleri* (Ragot) Wagner. Their charakteristics were complemented by a description of the cuticle structure and variability of pinnules statistically treated in the genera *Alethopteris bohemica* and *Alethopteris zeilleri*. *Alethopteris schneideri* is for the first time reported from the Permian on the Czechoslovak territory.

Earlier identified representatives of the genus Alethopteris from the Stephanian and Permian of Czechoslovakia: *Alethopteris costei* Zeiller (Purkyně 1929b, pl. I, fig. 1) belongs to the species *Praecallipteridium jongmansii* P. Bertr.) Wagner (Wagner 1963), *Alethopteris neessii* (Goepp.) Presl in Stbg. belongs to the genus *Callipteris* Bgt. (Franke 1912), *Alethopteris pteroides* (Bgt.) Gein. (Feistmantel 1885, pl. II, figs. 2—4) belongs to *Pecopteris polymorpha* Bgt. (Němejc 1934), *Alethopteris punctata* Augusta (Augusta 1927, pl. I, fig. 2, pl. II, figs. 1,2) is probably *Pecopteris* (*Scolecopteris*) *pseudobucklandii* (Andrae in Germar) Stur (Barthel 1981, p. 923).

### Introduction

The aim of this work is to characterize more precisely the youngest representatives of the genus *Alethopteris* Sternberg in Czechoslovakia. Variability of pinnule fronds, cuticles, geographic distribution and stratigraphic range are discussed. These data also permit to assess ecological demands of the described plants.

The paper is based on the study of material from the following collections (in the chapter on the occurrence and stratigraphic range the following abbreviations were used):

NM — National Museum, Prague
ÚÚG — Geological Survey, Prague
UK — Faculty of Science, Charles University, Prague
UJEP — Faculty of Science, J. E. Purkyně University, Brno

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| | |
|---|---|
| MM | — Moravian Museum, Brno |
| SM | — Silesian Museum, Opava |

The author's data on the occurrence, which rest mainly upon the material from mines and outcrops, supplement the notes after the late Dr. J. Šetlík (Š) describing prevailingly material from boreholes.

If a more precise lithostratigraphic classification of some specimens is known it is expressed by the following abbreviations:

| | |
|---|---|
| t | — Týnec Formation |
| j | — Jelenice Member |
| m | — Mšec Member |
| h | — Hředle Member |
| ko | — Kounov group of seams |
| kl | — Klobuky horizon |
| ra | — Radvanice group of seams |
| šč | — Štěpanice-Čikvásky horizon |
| sy | — Syřenov group of seams |

The author established the following species of the genus *Alethopteris* in limnic regions of the Bohemian and Moravian Stephanian and Permian:

*Alethopteris bohemica* FRANKE (Stephanian B) — Slaný Formation, Jívka Member, ?Stephanian C in the Blanice Furrow.

*Alethopteris zeilleri* (RAGOT) WAGNER (Stephanian B) — ?Týnec Formation, Slaný Formation, Jívka Member; (Stephanian C) — Líně Formation, Semily Formation, Blanice and Boskovice Furrows; (Autunian) — Boskovice Furrow.

*Alethopteris moravica* AUGUSTA (lowermost Autunian) — Boskovice Furrow.

*Alethopteris schneideri* (STERZEL) STERZEL (Autunian) — Boskovice Furrow.

### *Alethopteris* STERNBERG, 1825

A complete synonymy of the genus is listed in the work of JONGMANS (1957): Fossilium Catalogus, II. Plantae, pars 30, no. 3. Additional extensive synonymies are given in the works of BUISINE (1961, p. 65) and WAGNER (1968, p. 22).

1820 *Filicites* SCHLOTHEIM; Schlotheim, p. 411
1825 *Alethopteris* STERNBERG; Sternberg, p. 21

### *Alethopteris bohemica* FRANKE, 1912

Text-figs. 1–3, pl. I, figs. 1–6, pl. II, figs. 1–3

A comprehensive synonymy of the species was presented by WAGNER (1968).

1890 *Alethopteris aquilina* BRONG.; GRAND 'EURY, p. 290–291, pl. 21, figs. 3–6.
1912 *Alethopteris bohemica* n. sp.; FRANKE, p. 75–77, figs. 1–2.
1929a *Alethopteris Serli* BGT.; PURKYNĚ, p. 12–13, pl. 3, fig. 4, pl. 4, fig. 2.

1960 *Alethopteris bohemica* Franke; Obrhel, p. 86–91, pl. 1, figs. 1–4 [fragment of frond together with male fructifications ? *Dolerotheca fertillis* (Renault)], figs. 5–7 [pollen grains of the type *Schopfipollenites ovatus* (Schopf)], pl. 2, figs. 1,2 (*Schopfipollenites ovatus*).

1963 *Alethopteris bohemica* Franke; Barthel, p. 53–54, text. figs. 1–2 (structures of epidermis), pl. 1, fig. 1 (fragment of a frond), figs. 2–7 (structures of epidermis), pl. 2, figs. 1–9 (structures of epidermis).

1964 *Alethopteris bohemica* Franke; Havlena in Svoboda et al., p. 243, pl. 53, fig. 2.

1968 *Alethopteris bohemica* Franke; Wagner, p. 49–57, text-figs. 9, 10 (copies from Grand 'Eury, 1890, pl. 21, figs. 4, 4 A), pl. 9, figs. 29, 29a, 30, 30a (photographs of Franke's types, 1912, figs. 1, 2), figs. 31–32a, pls. 10–14, figs. 33–42a.

1977 *Alethopteris bohemica* Franke; Šetlík in Holub - Wagner, p. 315–340, pl. 12, fig.2.

Syntypes: Franke (1912), figs. 1,2 — deposited in Die Arbeitsstelle für Paläobotanik und Kohlenkunde der Deutschen Akademie der Wissenschaften, Berlin — quotation from Wagner (1968).

Type locality: Mine works between Slaný and Blahotice, Kladno Basin, Czechoslovakia.

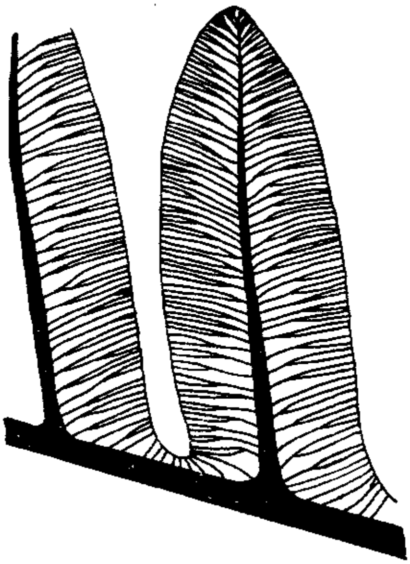
Type horizon: Slaný Formation, Otruby Member, Kounov group of seams — Stephanian B.

Material: Approximately 70 fragments of fronds preserved in grey siltstones to fine-grained sandstones.

Diagnosis: Wagner (1968).

Description: Fronds are imparipinnate into higher orders. Fronds of the last order are 15–45 mm wide. Rachises of the last order are 0,5–2 mm wide and up to 110 mm long (in uncomplete specimens).

Pinnules are tongue-shaped with bluntly pointed apexes and are set on the rachis of the last order at the angle of 55 through 75°. They are 5 to 20.5 mm long and 4 to 9.5 mm wide at the base and 4–9 mm wide in the middle of the pinnule. At the base the pinnules are connected with a rim which is usually 1 mm wide, in greater pinnules almost imperceptible and in younger pinnules up to 2.5 mm



1. Venation of pinnules of *Alethopteris bohemica* Franke, locality Libovice, Mine Jiřina 2, Stephanian B, ×4

wide. Terminal pinnule is small, relatively wide, of oval shape. It is terminated by a blunt apex 5—8 mm long and 3—5 mm wide.

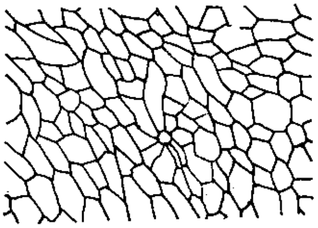
Venation is pennate. Midvein is thick, rigid, running almost straight through the leaf blade and is distinct even at the pinnule apex. Lateral veinlets branch off from the midvein into the blade, they are once or twice forked and reach the pinnule border at almost right angles. Lateral veinlets are fine and venation considerably dense (39 through 52 veinlets per 1 cm of pinnule border). Subsidiary veins running through the pinnule rim are straight or once forked.

Cuticles: Cuticles were prepared from the material from the borehole 8200/VI (pl. I, fig. 4).

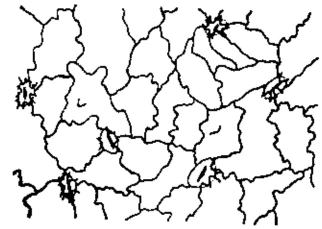
Adaxial cuticle (text-fig. 2, pl. I, fig. 6, pl. II, fig. 2): Cells are polygonal, unoriented and have a diameter of 40 to 50 μm. In costal and intercostal areas the cells are undistinct. Anticlinal walls are straight. Cuticles show fine-grained sculpturing. Rare hair bases on the adaxial cuticle are formed by one cell of circular shape with 20—25 μm in diameter. In the site of the midvein and rachis of the last order the adaxial cuticle has cells more oblongly oriented in the direction of the midvein and rachis.

Abaxial cuticle (text-fig. 3, pl. I, fig. 5): Epidermis very weakly cutinized and considerably disturbed in our specimen, cell outlines poorly visible. Costal and intercostal areas undiscernible. Cells are unoriented (approximately 1.5—2.5 times longer than wide), of irregular shape. They are 30 to 50 μm long and 15 to 25 μm wide. Anticlinal cell walls are undulated. Periclinal wall shows tiny weakly cutinized papillae of 10 μm in diameter which are poorly visible due to ill preservation.

Stomata weakly oriented, submerged below epidermis level and covered by papillae of subsidiary cells. Papillae on some subsidiary cells undiscernible.



2. Adaxial cuticle of *Alethopteris bohemica* FRANKE, central Bohemian region, Stephanian B, × 100



3. Abaxial cuticle of *Alethopteris bohemica* FRANKE, central Bohemian region, Stephanian B, × 250

Stomata are haplocheilic, monocytic, of anomocytic type, elliptical, 14—18 μm long and 10—12 μm wide. They are surrounded by 4—6 subsidiary cells of identical shape as that of a normal epidermal cell.

Cuticles of rachis of the last order and of the abaxial side of the midvein (pl. II, fig. 1): Cells are oriented and considerably elongated in the direction of the course of the midvein or rachis. They are trapezoidal to spindle-like in shape. Their anticlinal walls are straight or slightly bent. Cells are 90—180 μm long and 10—25 μm wide. Among these cells are scattered hair bases formed by one cell of 15—25 μm in diameter.

Comparison: The species *Alethopteris bohemica* FRANKE resembles the species *Alethopteris schneideri* (STERZEL) STERZEL. The latter species, however, exhibits relatively wider and more asymmetric pinnules with broadly rounded apexes.

*Alethopteris zeilleri* (RAGOT) WAGNER differs from *Alethopteris bohemica* FRANKE in having broadly rounded pinnule apexes and thinner venation (28 through 43 veinlets per 1 cm of pinnule border).

Comparison with the species *Alethopteris kanisi* WAGNER, *Alethopteris densinervosa* WAGNER, *Alethopteris pontica* ZEILER and *Alethopteris missouriensis* (D. WHITE) WAGNER was done by WAGNER (1968).

Remarks: NĚMEJC (1936) identified the species presented as *Alethopteris grandini* (non BRONGNIART) ZEILLER [present *Alethopteris zeilleri* (RAGOT) WAGNER] with the species *Alethopteris bohemica* FRANKE and from the Stephanian horizons of Bohemia reported solely the species *Alethopteris bohemica* FRANKE. It turned out later that this assumption had been wrong and at the present two species of the genus *Alethopteris* has been reported from the Stephanian of Bohemia.

Besides two findings from the Stephanian C of the Blanice Furrow classified as *Alethopteris* cf. *bohemica* FRANKE, this species occurs in the Stephanian B of the central Bohemian region. The most abundant findings were made in the Plzeň Basin (see table 2). *Alethopteris bohemica* is most frequently preserved in grey siltstones, clayey-sandy rocks to fine-grained sandstones. Rarely it occurs also in pelite-carbonate rocks of the Kounov group of seams and light-coloured tuffaceous rocks locally called "kamínek". Due to ill-preserved coal mass in coarser rocks it is difficult to prepare cuticles from this species.

Cuticles of *Alethopteris bohemica* prepared by the author are similar to those prepared by BARTHEL (1963) in shape and size of the cells and stomata on the abaxial cuticle. Cells of the adaxial cuticle are smaller compared with those of BARTHEL. Hair bases on the adaxial cuticle and in the site of the midvein have 20—25 μm in diameter while on the cuticles prepared by BARTHEL (1963) the hair bases (described as papillae by BARTHEL) exhibit about 40 μm in diameter (see table 1).

According to the character of preservation in the rock and structure of cuticle (abaxial cuticle exhibits xenomorphic features) this species corresponds to specimens of the Stephanian extra-seam flora which probably grew on margins of coal-bearing basins.

Occurrence and distribution: Central Bohemian region, Slaný Formation, Stephanian B.

Plzeň Basin: Chotíkov (NM, Š) – gulch, boreholes Co-3 (ko), Co-11, Cho-1 (ko), Cho-2 (ko), V-48, 56, 58, 62, 63, Ledce (Š) – borehole LV-2, Líně (Š) – borehole PP-11 (j), Lochotín (Š) – outcrops in an antiaircraft shelter, Nevřeň (Š) – borehole Ge-37, Radčice (ÚÚG, Š) – borehole PP-1 (base of the Slaný Formation), pit Š-80, Tlučná (NM, Š) – Mine Krimich II (ko), borehole Tl-1 (j), Třemošná (Š) – borehole Tř-10, Vejprnice (Š) – boreholes Vj-3 (m), Vj-8 (j, ko), Ves Touškov (Š) – borehole VT-1 (j), V Propastech (Š) – material from a well, ?Žilov (Š) – borehole Ge-45. Rakovník Basin: Děkov (Š) – s. of the road Děkov – Nová Ves, e. of the village, Chrášťany (Š) – borehole Chr-18 (ko), Kounov (NM) – Mine Kateřina (ko), Kroučová (NM, Š) – Mine Adolf (ko), borehole Kr-11 (ko), Rakovník (NM) – n. of the town, Záboř (NM). Kladno Basin: Dolín (Š) – borehole Dl-2 (m, h), Drnov (Š) – borehole Dv-1 (ko), Hobšovice (Š) – borehole Hš-1 (ko), Kralupy (NM), Kvílice (NM) – Mine Magdalena (ko), Libovice (NM, ÚÚG) – Mine Jiřina 2 (ko), Plchov (ÚÚG) – refuse pile, Skury (Š) – borehole Sy-1 (m), Slaný (NM) – Mine Caroli (ko). Mšeno Basin: Chloumek (Š) – borehole MB-3 (m), Jelenice (Š) – borehole MJ-1 (m).

?Lugicum area, Jívka Member, Stephanian B. Intrasudetic Basin: Žabokrky (Havlena 1956, Němejc 1958).

*Alethopteris* cf. *bohemica* Franke, Stephanian C.

Blanice Furrow: Dolní Peklov near Kostelec n. Černými lesy (NM).

### *Alethopteris zeilleri* (Ragot, 1955) Wagner, 1958

Text-figs. 4–8; pl. II, figs. 4–7; pls. III–VIII

Extensive synonymy of the species is presented in Wagner (1968).

1888 *Alethopteris Grandini* Brongniart (sp.); Zeiller in Renault - Zeiller, p. 203–207, pl. 21, figs. 1–4, (? fig. 5), figs. 6–8.

1899 *Alethopteris Grandini* Goepp.; Hofmann - Ryba, pl. 8, figs. 4,5.

1899 *Alethopteris Serli* Brongn.; Hofmann - Ryba, pl. 8, fig. 2.

1936 *Alethopteris bohemica* Franke; Němejc, p. 2–8, text-fig. 1a, b, pl. 1, fig. 1.

1955 *Alethopteris grandini* forma *zeilleri*: Ragot, p. 47–56, pl. 7, fig. 3 (after Wagner, 1968).

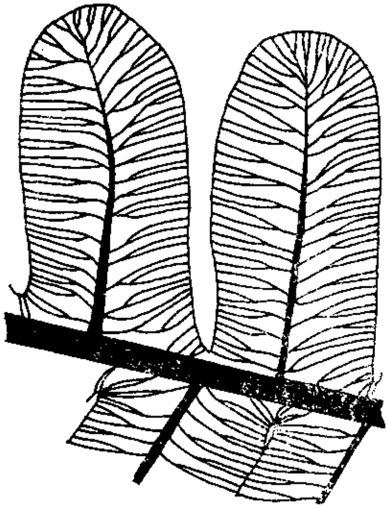
1958 *Alethopteris zeilleri* Ragot; Wagner - Breimer, p. 18.

1968 *Alethopteris bohemica* Franke; Němejc, p. 169, pl. 20.

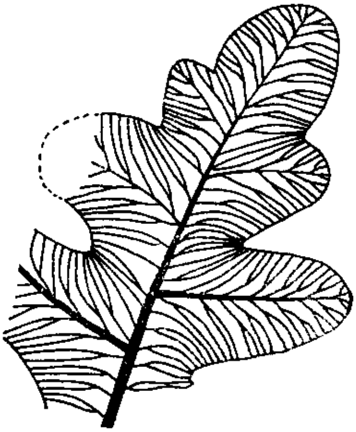
1968 *Alethopteris zeilleri* Ragot; Wagner, p. 158–169, text-fig. 52–55, pl. 63, figs. 176–178, pl. 64, figs. 179–181a.

1977 *Alethopteris zeilleri* (Ragot ex Remy et alii); Šetlík in Holub - Wagner, p. 315–340, pl. 12, fig. 1.

Holotype: Zeiller (1888), pl. 21, fig. 8 – datum from Wagner (1968).
Type locality: Commentry, pit Forêt, 8th level, France.
Type horizon: Seam Roseaux, Stephanian, Carboniferous.
Material: More than 200 fragments of fronds preserved in grey to black mudstones, coal claystones, in some places in siderite concretions.
Diagnosis: Wagner (1968).



4. Venation of pinnules of *Alethopteris zeilleri* (Ragot) Wagner, locality Kvílice, Mine Magdalena, Stephanian B, ×4



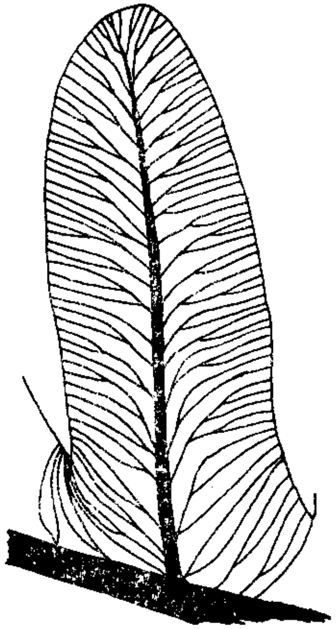
5. Venation in the terminal part of the pinna of the last order of *Alethopteris zeilleri* (Ragot) Wagner, locality Kvílice, Mine Magdalena, Stephanian B, ×4

Description: Fronds are imparipinnate into higher orders. Rachis of the last order is up to 1.5 mm wide. Fronds of the last order are 50 to 220 mm long and 15 to 40 mm wide. Rachises of the last but one oder are up to 2.5 mm thick.

Pinnules are tongue-shaped with broadly rounded apexes. With the rachis of the last order they contain an angle of 55 to 80°. Length of pinnules is 6 to 24.5 mm, width at the base 4–11 mm and 4–10 mm in the middle of the pinnule. Pinnules at the base are conjoined by a rim usually 1 mm wide. Sometimes the rim is narrower, almost imperceptible. Conversely, in younger pinnules it can reach width of over 2 mm. Terminal pinnule is small, relatively broad, with rounded apex. Its length is 4–8 mm, width 3–5 mm.

Venation is pinnate. Midvein is conspicuous and usually follows a straight course through the lamina. Lateral veins branch off from the midvein, they are once or twice forked, predominantly follow a straight course towards the pinnule margin which is attained at almost right angle. Venation is rather thin (28–43 veins per 1 cm of the pinnule margin). Subsidiary veins entering the pinnule rim are usually bifurcated, branching off directly from the rachis of the last order.

Cuticles: Cuticles were prepared from the material from Kvílice, Mine Magdalena (pl. III, fig. 1), from Libovice, Mine Jiřina 2 (pl. II, fig. 6) and from Oslavany, Mine Kukla (pl. VIII, fig. 4).



6. Pinnule venation of *Alethopteris zeilleri* (RAGOT) WAGNER, locality Oslavany, Mine Kukla, Stephanian C, ×4

Adaxial cuticle (pl. IV, pl. VI, fig. 6, pl. VII, figs. 2, 3, text-fig. 7): Cells in the costal and intercostal areas differ in shape. Cells of the costal area are markedly oriented parallel to the venation and are 60 to 100 μm long and 20 —35 μm wide. They are usually quadrangular with undulated anticlinal walls.

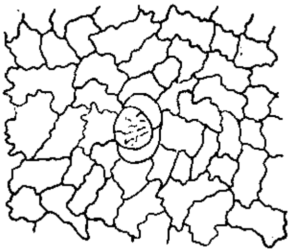
Cells in the intercostal region are unoriented, of irregularly polygonal shape, occasionally elongated, 60 —80 μm long and 30 —60 μm wide. Anticlinal walls are undulated. The cuticle shows fine-grained sculpturing.

Adaxial cuticle exhibits irregularly dislocated hair bases of ovate shape and 80 —100 μm in diameter. The hair basis is surrounded by 6 —8 subsidiary cells which are similar to other cells in the intercostal area.

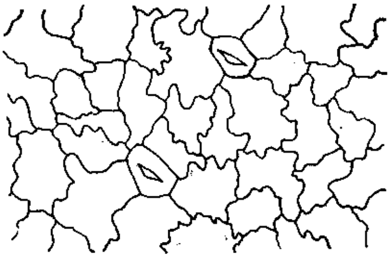
Hairs (pl. VII, figs. 2, 3) are simple, uniseriate. Terminal parts of hairs are formed by 6 —8 cask-shaped cells. Hairs are up to 230 μm long and 55 —65 μm wide. All their apexes are broken.

Abaxial cuticle (text-fig. 8, pl. III, fig. 2, pl. VI, figs. 3, 4): Abaxial cuticle is very weakly cutinized. Cells of the intercostal and costal areas are differentiated. Cells in the costal area are longitudinally oriented in the direction of lateral veins. Intercostal cells show papillae and wavy anticlinal walls. Cells are irregularly polygonal, unoriented, 30 —50 μm long and 20 —30 μm wide.

In the intercostal area irregularly scattered anomocytic stomata of monocyclic type are present. Stomata are widely elliptical, up to 24—28 μm long and 16—20 μm wide, surrounded by 5—6 subsidiary cells of almost identical shape and size as that of normal epidermal cells.



7. Adaxial cuticle of *Alethopteris zeilleri* (RAGOT) WAGNER, locality Libovice, Mine Jiřina 2, Stephanian B, × 100



8. Abaxial cuticle of *Alethopteris zeilleri* (RAGOT) WAGNER, locality Libovice, Mine Jiřina 2, Stephanian B, × 250

Cuticles of the rachis of the last order and of abaxial side of the midvein (pl. II, fig. 7, pl. VI, figs. 1, 2, 5): Cells are elongated in the direction of the rachis or midvein course, quadrangular, with straight anticlinal walls. They are 40—100 μm long and 20—30 μm wide. Between these cells are frequently found hair bases of broadly elliptical shape and more strongly cutinized than other cuticles. The hair basis is formed by a pair of rounded cells which set on a larger epidermal cell having 70—90 μm in diameter (pl. VI, fig. 2). Hairs are simple, uniseriate and are formed by approximately 5 cells. Hair apexes are unknown. Some hairs have the second basal cell considerably narrow (pl. VI, fig. 1). The hairs are 45—50 μm wide and up to 350 μm long.

Cuticles examined by electron microscope (SEM) (pl. V, figs. 1—3): Adaxial cuticle (pl. V, figs. 1, 2). Cell contours are indistinct, periclinal walls wavy and bear plenty of flat bulges of 10—20 μm in size. Surface of the bulges is furrowed into tiny ridges 2—3 μm wide. Minute rounded formations are probably traces after corrosion (pl. V, fig. 2).

Abaxial cuticle (pl. V, fig. 3). Outlines of cells on the abaxial cuticle are not even apparent. Papilla is elliptical, 15 μm long and 9 μm wide. Its vicinity shows radially arranged furrows. Otherwise, the surface of the abaxial cuticle is smooth and bears tiny round formations 1—4 μm in diameter, probably traces after corrosion.

Comparison: *Alethopteris zeilleri* (Ragot) Wagner has pinnules very similar to the pinnules of the species *Alethopteris grandinioides* Kessler but their venation differs. Lateral veins in *Alethopteris grandinioides* are broadly branched and inserted obliquely to the pinnule border while the veinlets in *Alethopteris zeilleri* follow a straight course perpendicularly to the pinnule border. *Alethopteris grandinioides* has thinner venation with 20–26 veinlets per 1 cm of pinnule border while *Alethopteris zeilleri* exhibits 28–43 veinlets per 1 cm of pinnule border. Terminal pinnules of *Alethopteris grandinioides* are longer and narrower than those of *Alethopteris zeilleri.*

*Alethopteris serlii* (Brongniart) Goeppert has pinnules with convex borders and bluntly pointed apexes while the pinnules of *Alethopteris zeilleri* have straight borders and broadly rounded apexes. *Alethopteris serlii* occurs in the Westphalian and *Alethopteris zeilleri* is reported from the Stephanian.

*Alethopteris grandini* (Brongniart) Goeppert differs from *Alethopteris zeilleri* (Ragot) Wagner in having smaller pinnules with convex borders. *Alethopteris grandini* has arched veinlets and thinner venation (25–30 veinlets per 1 cm of pinnule border. The veinlets in *Alethopteris zeilleri* follow almost a straight course and the venation is more dense (28–43 veinlets per 1 cm of pinnule border).

*Alethopteris bohemica* Franke differs from *Alethopteris zeilleri* in exhibiting more dense venation (39–53 veins per 1 cm of pinnule border), thicker midvein and bluntly pointed apex of the pinnule.

Wagner (1968) published a comparison of *Alethopteris zeilleri* (Ragot) Wagner with other species: *Alethopteris pennsylvanica* Lesquereux, *Alethopteris magna* Grand 'Eury, *Alethopteris distantinervosa* Wagner and *Alethopteris barruelensis* Wagner.

Relationship: Wagner (1968) presumes that in northwestern Spain the species *Alethopteris zeilleri* (Ragot) Wagner developed from the species *Alethopteris grandinioides* Kessler via the variety *Alethopteris grandinioides* Kessler var. *subzeilleri* Wagner in the Westphalian D through the lower Stephanian A.

Remarks: Němejc (1936) held the specimens of the species *Alethopteris bohemica* described by Franke (1912) for a special mode of preservation of the species *Alethopteris grandini* Zeiller (non Brongniart) and that is why he ranged all the specimens of the *Alethopteris* species from the Stephanian of Bohemia with the single species *Alethopteris bohemica* Franke.

*Alethopteris zeilleri* is abundant in the Stephanian. It is known predominantly from mining works in central Bohemian region, namely from the Kladno Basin since it occurs most probably close to seams. It is frequently found in grey to black-grey mudstone rocks in which it is usually preserved in the state suitable for preparation of cuticles. It is often found also in siderite concretions. In younger sediments (Stephanian C–Autunian) this species becomes rare and is preserved also in grey or sometimes brownish siltstones.

I got an opportunity to study several specimens of *Alethopteris zeilleri* from the

Permian of the Boskovice Furrow which are deposited in the collections of the Moravian Museum in Brno. Augusta classified them as *Alethopteris grandini*. In this collection many specimens of the species *Callipteris conferta* (STERNBERG) BRONGNIART were also ranged under the same name.

Cuticles of *Alethopteris zeilleri* from Bohemia are identical with the cuticles depicted in the work of BOUREAU (1975) on fig. 294 bis.

The species *Alethopteris zeilleri* corresponds with the elements of the Stephanian seam-forming flora by its mode of preservation in the rocks and by the cuticle structure (abaxial cuticle shows mesomorphic features). By the end of the Stephanian and in the Permian *Alethopteris zeilleri* probably replaced the species *Alethopteris bohemica* FRANKE also in the marginal parts of the basins.

Occurrence and distribution: Central Bohemian region, Slaný Formation, Stephanian B.

Plzeň Basin: Líny (NM) – (ko), Mrtník (Š) – borehole KZ II [?t (Stephanian A), base of the Slaný Formation], Ves Touškov (Š) – borehole VT-1 (j).

Rakovník Basin: Děkov (Š) – s. of the road Děkov–Nová Ves, cut in the road to Vlkov, Rakovník (NM) – n. of the town, Záboř (NM).

Kladno Basin: ?Dolín (Š) – borehole Dl-1 (h), Hobšovice (Š) – borehole Hš-1 (m), Jedomělice (Š) – borehole M2, Kněževes (Š) – borehole Kn-25 (ko), Kralupy (NM), Kvíc (Š) – borehole Kc-2a (m), Kvílice (NM) – Mine Magdalena (ko), Libovice (NM, ÚÚG) – Mine Jiřina 2 (ko), Lotouš (UK) – Mine Jiřina 1 (ko), Sazená (Š) – borehole Sz-1, ?Slaný (Š) – boreholes Sa-9 (m), Sa-11, Trpoměchy (Š) – borehole Ty-1, Tuřany – Hvězda (NM) – abandoned claim near the road (ko), Vítov (Š) – borehole Vt-1 (ko), Zlonice –Páleček (Š) – borehole Z-16, ?Zvoleněves (Š) – borehole B3.

Mšeno Basin: Hleďsebe (Š) – borehole MB-6 (m).

Líně Formation, Stephanian C.

Kladno Basin: Klobuky (Š) – outcrop e. of sugar factory (kl.).

Lugicum area.

Krkonoše Piedmont Basin: Syřenov Formation, Stephanian B – Syřenov (Š) – borehole Sy-3, Ústí (Š) – borehole UT-2, Semily Formation, Stephanian C – Čikvásky (NM) – (šč), Nedvězí (NM, UK) – pit tip B (šč), Štěpanice (NM) – (šč), Tužín (ÚÚG).

Intrasudetic Basin: Jívka Member, Stephanian B – Chvaleč (SM) – borehole Chv-3 (ra).

Furrow region. Blanice Furrow, Stephanian C: *Alethopteris* cf. *zeilleri*, Dolní Peklov near Kostelec nad Černými lesy.

Boskovice Furrow, Rosice-Oslavany group of seams, Stephanian – lowermost Autunian: Babice near Zastávka (NM) – Mine Ferdinand, Oslavany (NM, SM, ÚÚG) – Mine Nosek, Zbýšov (NM, MM, ÚÚG) – Mine Antonín, top wall (between the 1st and 2nd seam), top wall of the 2nd seam. Grey horizons in the main red-brown formation, Autunian: Zbýšov (MM).

## *Alethopteris moravica* AUGUSTA, 1927

Text-fig. 9; pls. IX–XI; pl. XII, figs. 1–4

1927 *Alethopteris moravica* n. sp.; AUGUSTA, p. 3–6, text-fig. 1a,b, pl. 1, fig. 1.
1967 *Alethopteris moravica* AUGUSTA: WAGNER, p. 53–55, pl. 5, figs. 1, 1a, 1b (photograph of holotype and its details).

Holotype: AUGUSTA (1927), text-fig. 1a,b, pl. 1, fig. 1. Holotype is deposited in the Department of Geology and Palaeontology, Faculty of Science, Jan Evangelista Purkyně University in Brno under the number E 3961.

Type locality: Zastávka near Rosice, pit Julius, Rosice-Oslavany Basin, Boskovice Furrow, CSSR.

Type horizon: Rosice-Oslavany group of seams, surroundings of the 1st (main) seam, lowermost Autunian, Permian.

Material: Three fragments of fronds preserved in grey mudstones.

Diagnosis: WAGNER (1967).

Description: Only fragments of pinnae of the last order are known; the longest fragment measures 80 mm (pl. X, fig. 1), the broadest is 30 mm wide (pl. IX, fig. 3). Rachis of the last order is narrow, up to 1 mm thick, gently flexuose, in the basal part straight, with fine longitudinal ridges (pl. IX, fig. 3).

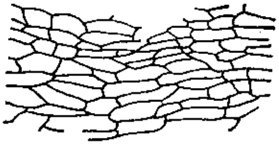
Pinnules set on the rachis of the last order at angles of 50 to 70°, they are asymmetric, on the basiscopis side running down the rachis of the last odrer. Pinnules are mutually joined with a rim which is narrow, in places almost imperceptible even in small pinnules. Its greatest width is 1.5 mm, incisions between pinnules are acute. Pinnules have convex margins and bluntly pointed apex, they are 3 to 4 times longer than broad, they are 7–21 mm long and 3–6 mm broad in the middle and 4–7 mm broad at the base of the pinnule.

Midvein is distinct, straight or secondarily bent, reaching almost the apex of the pinnule. Venation is dense (55–65 veins per 1 cm of pinnule border). Lateral veins are once or rarely twice forked, they branch off from the midvein at sharp angles, they are arcuate and reach the pinnule margins almost perpendicularly. Subsidiary veins on the basiscopic side are simple or once forked.

Cuticles: Cuticles were prepared from holotype and another specimen determined by J. Augusta as *Alethopteris decurrens*. Both specimens come from Zastávka near Rosice and the cuticles confirm that they belong to one species.

Adaxial cuticle (text-fig. 9, pl. IX, fig. 5, pl. XI, figs. 3, 4, pl. XII, figs. 1–4): Cells are weakly cutinized, discernible in costal and intercostal areas, they are oriented in the direction of lateral veinlets and exhibit elongated quadrangular to pentagonal shape. In the costal area they are longer (60–100 μm long and 10–20 μm wide) than in the intercostal area (40–70 μm long and 15–30 μm wide). Anticlinal walls are straight or moderately bent. The cell walls in the costal area are probably more strongly cutinized than those in the intercostal area since after maceration only stripes of cells above lateral veins were preserved while the cells in the intercostal areas disintegrated into small fragments.

Abaxial cuticle (pl. X, figs. 5, 6, pl. XI, fig. 5): Abaxial cuticle is very weakly cutinized and therefore during maceration it disintegrates into small fragments. The cell walls are indistinct and the cuticle rather corroded. The shape of the cells is probably irregularly polygonal, cells are unoriented, 1.5 to 2 times longer than wide, 40—70 μm long and 20—40 μm wide. Anticlinal walls are undulated. Stomata are indiscernible due to poor preservation.



9. Adaxial cuticle of *Alethopteris moravica* AUGUSTA, locality Zastávka, Mine Julius, lowermost Autunian, × 100

Cuticle in the site of the midvein (pl. XI, figs. 1, 2): Cells are strongly oriented parallel to the course of the midvein, elongatedly quadrangular in shape, 80—150 μm long and 15—35 μm wide. Anticlinal walls are straight or mildly bent. Between these cells occur hair bases which are formed by a single elliptical cell 45 μm long and 30 μm wide (pl. XI, fig. 1).

Hairs (pl. X, fig. 4, pl. XI, figs. 6—8): Hairs grew probably in the site of the midvein and above the pinnule veins. They are simple, uniserial cover hairs formed by up to 6 cask-shaped cells, 70—95 μm wide and up to 500 μm long. They were identified only in the paratype Alethopteris moravica, holotype exhibits only hair bases of a smaller diameter than that of the above described hairs. The hair bases are composed of one cell with a diameter about 45 μm.

Comparison: *Alethopteris moravica* AUGUSTA differs from the remaining species of the genus *Alethopteris* STERNBERG, beside other features, in having more dense venation. A similar venation density exhibit also the Namurian through the lower Westphalian species *Alethopteris decurrens* (ARTIS) ZEILLER (52—76 veins per 1 cm of the pinnule border) according to the measuring performed on the material from the Intrasudetic Basin.

*Alethopteris lonchitica* shows relatively longer pinnules than *Alethopteris moravica*, pinnule borders are parallel, in smaller pinnules convex. *Alethopteris moravica* has asymmetrical pinnules which are convex only on the acroscopic side of the pinnule. Lateral veins of *Alethopteris lonchitica* are once or twice forked, they branch off the midvein in a small arch and follow a straight course through the pinnule lamina almost perpendicularly to the pinnule border. *Alethopteris moravica* shows once or twice forked lateral veins running an arched course through the pinnule lamina and reach the pinnule border almost perpendicularly.

*Alethopteris decurrens* (ARTIS) ZEILLER has narrower and usually longer pinnules than *Alethopteris moravica*, which exhibits pinnules 3 to 4 times longer than wide. In *Alethopteris decurrens* the pinnules are 5 to 10 times longer than wide and have a greater distance between individual pinnules in comparison with *Alethopteris* *moravica*. Lateral veins of *Alethopteris decurrens* are once forked, rarely undivided arching from the midvein and reaching the pinnule border somewhat obliquely.

Augusta (1927) presented a comparison with the following species: *Alethopteris decurrens* (Artis) Zeiller and *Alethopteris lonchitica* (Schlotheim) Zeiller.

Wagner (1967) presented a comparison with the following species: *Alethopteris leonensis* Wagner, *Alethopteris missouriensis* (D. White) Wagner, *Alethopteris westphalensis* Wagner, *Alethopteris robusta* Lesquereux var. *longipinnata* Wagner and *Alethopteris lesquereuxii* Wagner.

Remarks: When describing this species, Augusta (1927) and Wagner (1967) had only holotype. I have found another specimen of *Alethopteris moravica* referred by Augusta to *Alethopteris decurrens* (pl. X, fig. 1) in the collections of the Faculty of Science, J. E. Purkyně University, Brno. It has longer pinnules than the holotype but the venation in both the specimens is identical. The third specimen of *Alethopteris moravica* is deposited in the National Museum, Prague and it was determined by J. Augusta as *Alethopteris bohemica* (pl. IX, fig. 3) and represents the basal part of the pinna of the last order with considerably long pinnules secondarily bent towards the pinna apex and thus resembling at the first sight *Alethopteris decurrens*. However, the type of venation and broader pinnules than those of *Alethopteris decurrens* suggest that the specimen should be classified as *Alethopteris moravica*.

On the basis of remarks obtained on the Faculty of Science, J. E. Purkyně University, Brno, F. Němejc assumed that *Alethopteris moravica* is a terminal part of the pinna of some already described *Alethopteris*.

I endorse the opinion of Augusta (l.c.) that *Alethopteris moravica* is a rare endemic species hitherto known from a single locality in the Rosice-Oslavany Basin and can be well distinguished from the remaining species of the genus *Alethopteris* especially on the basis of venation density. The last reported occurrence of the species with a similar venation density is from the Westphalian A while *Alethopteris moravica* is known from the lowermost Autunian.

Occurrence and distribution: Boskovice Furrow, Rosice-Oslavany Basin, Zastávka near Rosice (UJEP, NM), pit Julius, Ist seam — lowermost Autunian.

2.5. –

### *Alethopteris schneideri* (Sterzel, 1881) Sterzel, 1918

Text-fig. 10; pl. XII, figs. 5, 6

17

1881 *Callipteridium Schneideri* nov. sp.; Sterzel, p. 262.

1918 *Alethopteris schneideri* Sterzel; Sterzel, p. 289, pl. 9, fig. 93, pl. 10, figs. 92, 92a, 94, pl. 15, fig. 93a.

1962 *Alethopteris schneideri* Sterzel; Barthel, p. 35—36, figs. 54—55 (cuticles), pl. 16, figs. 2—6 (cuticles), pl. 17, figs. 1 and 2.

1964 *Alethopteris schneideri* Sterzel; Reichel - Barthel, p. 212, fig. 2, pl. 6, figs. 3,4, pl. 5, pl. 7, figs. 3 and 4, pl. 8, figs. 11, 12, pl. 9, figs. 2, 3, pl. 10, figs. 2, 3.

1976 *Alethopteris schneideri* Sterzel; Barthel, p. 881—883, fig., pl. 1 and 2.

Lectotype: STERZEL (1918) pl. 10, fig. 94, deposited in the collections of GFE Freiberg (after BARTHEL 1976).

Type locality: Krušné hory Mts. basins, Oelznits, Deutschland-Schacht, depth 501 m, "Wildes Kohlengebirge", GDR.

Type horizon: Härtensdorf Member, Autunian, Permian.

Material: 2 specimens preserved in grey mudstones.

Diagnosis: BARTHEL (1976).

Description: Pinnules are convergent, tongue-shaped, with broadly rounded apex. Pinnule borders are convex, pinnules are 5—7 mm long, at the base 5 mm and in the middle 4—4.5 mm wide.

10. Pinnule venation of *Alethopteris schneideri* (STERZEL) STERZEL, locality Zbýšov, Autunian, × 4

Midvein is broad, distinct and persists almost to the pinnule apex. From the midvein commence at sharp angles once or twice forked lateral veins and curve gradually to reach the pinnule border somewhat obliquely. Lateral veins bifurcate from the rachis of the last order and are usually once or twice divided. Venation is rather dense 42—48 veinlets per 1 cm of pinnule border).

Cuticles: Cuticles could not be prepared from the Moravian material.They were detailedly described by BARTHEL (1962) and REICHEL and BARTHEL (1964).

Comparison: *Alethopteris schneideri* (STERZEL) is very similar to *Alethopteris bohemica* FRANKE, however, the latter exhibits relatively narrower pinnules and bluntly pointed apexes. The veins in *Alethopteris bohemica* follow a straight course almost perpendicularly to the pinnule border, in *Alethopteris schneideri* they curve away somewhat obliquely to the pinnule border. The appearance of the pinnules in *Alethopteris schneideri* is more asymmetrical.

*Alethopteris schneideri* differs from *Alethopteris zeilleri* in having more dense venation and asymmetrical appearance of the pinnules.

*Alethopteris schneideri* cannot be mistaken for the species *Alethopteris moravica*. *Alethopteris moravica* has even more dense venation and bluntly pointed pinnule apexes.

Remarks: I have learnt about the occurrence of the species *Alethopteris schneideri* (STERZEL) STERZEL in the Permian of Moravia from the materials after the late J. Šetlík in which I found also photographs of two species from the Boskovice Furrow taken by BARTHEL (fig. 10, pl. XII, figs. 5, 6). Both specimens are deposited in the Moravian Museum in Brno. They were studied by BARTHEL there in 1976. On my visit to the Moravian Museum I had an opportunity to examine only the better preserved specimen from Zbýšov. I had not seen the second specimen which was described by BARTHEL from Moravský Krumlov in 1976. The overall appearance of the pinnules and venation unmistakably suggest that these specimens belong to the species *Alethopteris schneideri* (STERZEL) STERZEL. So far, they represent the only finds of this species in Czechoslovakia.

Occurrence and distribution: Boskovice Furrow, grey horizons in the main red-brown formation, Autunian: Zbýšov (MM), Moravský Krumlov (MM).

## Results of investigation of the present material

### *Fructifications*

Fructifications of *Alethopteris moravica* AUGUSTA and *Alethopteris schneideri* (STERZEL) STERZEL are unknown.

NĚMEJC (1936) described seeds which were frequently found together with the pinnules of *Alethopteris bohemica* NĚMEJC (1936) = *Alethopteris zeilleri* (RAGOT) WAGNER. From the Bohemian region NĚMEJC (1936) described 2 kinds of seeds of the type *Pachytesta* BRONGNIART.

Large elliptical seeds 6—8 cm long and 4—5 cm wide, collected in the Kladno and Rakovník Basins (1 finding from Chotíkov in the Plzeň Basin) NĚMEJC (l. c.) assigned to the species *Pachytesta insignis* K. FEISTMANTEL and compared it with the species *Pachytesta gigantea* GRAND 'EURY.

In the Plzeň and rarely in the Rakovník Basins (Kounov) NĚMEJC (1936) found smaller seeds 4—5 cm long and approximately 2.5 cm wide, with distinct longitudinal ridges, and assigned them to the *Pachytesta* sp.

NĚMEJC (1936) was not able to interpret the parallel occurrence of two types of seeds with one plant species: "The fact that fronds of *Alethopteris bohemica* FRANKE are found in associations with seeds of two various kinds, points that we have not yet any definitive information as to the plants which bore the mentioned *Pachytesta* seeds."

On the basis of the present knowledge I assume that the seeds of *Pachytesta insignis* K. FEISTMANTEL belong to the species *Alethopteris zeilleri* (RAGOT) WAGNER with the most abundant occurrence in the Kladno Basin and the seeds of *Pachytesta* sp. (NĚMEJC 1936) are affiliated with the species *Alethopteris bohemica* FRANKE, which is also very abundant in the Plzeň Basin.

Male fructifications are known only from the species *Alethopteris bohemica* FRANKE. They are large bell-shaped synangia of the type ?*Dolerotheca fertilis* (RENAULT) HALLE (OBRHEL 1960), with large pollen grains of the type *Schopfipollenites ovatus* (SCHOPF).

### *Cuticles*

Cuticles are known from all the species of the genus *Alethopteris* STERNBERG occurring in the Stephanian and Permian on the territory of Bohemia and Moravia (see table 1).

The cuticles of all the four species differ from each other. Cells on the abaxial cuticle in the site of the midvein and rachis of the last order are most alike. Here are the cells of all the described species markedly longitudinally quadrangular, with straight or bent anticlinal walls oriented parallel to the midvein or rachis. Between these cells are situated hair bases of various sizes according to the species. Such cuticles were observed also in other genera (e. g. *Neuropteris* BRONGNIART). Hair bases occur also on the adaxial cuticle in *Alethopteris bohemica* FRANKE and *Alethopteris zeilleri* (RAGOT) WAGNER, and on the abaxial cuticle in *Alethopteris schneideri* (STERZEL) STERZEL. Hairs were found in the species *Alethopteris moravica* AUGUSTA and *Alethopteris zeilleri* (RAGOT) WAGNER. They are multicellular, simple, uniserial cover hairs, up to 0.5 mm long. The remaining species exhibited no hair; they either fell off already in the early life of the plant or disappeared due to unfavourable deposit conditions.

Cells of the abaxial cuticle show irregularly polygonal shape with undulated anticlinal walls; only *Alethopteris schneideri* (STERZEL) STERZEL has straight or mildly bent anticlinal walls.

Stomata in all the species are haplocheilic, monocyclic, of an anomocytic type. However, they differ in size, presence of papillae on subsidiary cells and sinking of the stoma. Stomata in *Alethopteris bohemica* are sunken below the level of the epidermis and subsidiary cells exhibit papillae. In *Alethopteris schneideri* the stomata are sunken and subsidiary cells are without papillae. *Alethopteris zeilleri* has stomata on the epidermis level and subsidiary cells without papillae.

Features like sinking of the stoma below the epidermis level, papillae or thickened walls of the subsidiary cells which superimpose the stoma are considered as xeromorphic.

They occur in plants restricting transpiration out of two reasons: a) the plants grow on dry habitats with lack of water, b) the plants grow in boggy environment with a surplus of humic acids, low pH value and lack of nitrogen accessible by plants (physiologic dryness).

Xeromorphic features are manifest in *Alethopteris bohemica* and *Alethopteris schneideri*. According to the environment in which these species were found I presume that they truly grew in dry places of coal-bearing basins or in the vicinity of episodic lakes.

The species *Alethopteris zeilleri* with mesomorphic features represents a typical element of hygrophylous seam-forming flora.

Adaxial cuticles of the described species differ from each other. *Alethopteris bohemica* has unoriented polygonal cells with straight anticlinal walls, *Alethopteris*

Table 1

Most important features of cuticles in described species of the genus *Alethopteris* STERNBER

| | abaxial cuticle | | | | | |
|---|---|---|---|---|---|---|
| | differentiation of costal and intercostal area | cell orientation | cell shape | anticlinal walls | cell size (intercostal area) (μm) | |
| | | | | | length | width |
| *A. bohemica* (M. Barthel 1963)<br>loc. Libovice | distinct | unoriented | irregular | mildly undulated | 35—50 | |
| *A. bohemica*<br>loc. borehole 8200/IV | indistinct | unoriented | irregular | mildly undulated | 30—50 | 15—25 |
| *A. moravica*<br>loc. Zastávka near Rosice | ? | ? unoriented | ?irregular | undulated | 40—70 | 20—40 |
| *A. schneideri* (M. Barthel 1962, W. Reichel - M. Barthel 1964)<br>Krušné hory Mts. basins | very distinct | unoriented | irregularly polygonal | straight to mildly bent | 20—40 | |
| *A. zeilleri*<br>loc. Libovice, Kvílice | distinct | unoriented | irregularly polygonal | undulated | 30—50 | 20—30 |

| | adaxial cuticle | | | | |
|---|---|---|---|---|---|
| | differentiation of costal and intercostal area | intercostal area | | | |
| | | cells (orientation and shape) | anticlinal walls | all size (μm) | |
| | | | | length | width |
| *A. bohemica* (M. Barthel 1963) | none | unoriented, polygonal | straight | 50—80 | |
| *A. bohemica* borehole 8200/IV | none | unoriented polygonal | straight | 40—50 | |
| *A. moravica* | distinct | strongly oriented, longitudinally quadrangular | straight to mildly bent | 40—70 | 15—30 |
| *A. schneideri* | indistinct | longitudinally oriented, irregularly polygonal to rectangular | straight to mildly bent | 60—150 | 20—50 |
| *A. zeilleri* | distinct | unoriented, irregularly polygonal | undulated | 60—80 | 30—60 |

ab. — abaxial, ad. — adaxial

Table 1

| abaxial cuticle | | | | | | |
|---|---|---|---|---|---|---|
| stomata | | | | subsidiary cells of the stoma | | |
| orientation | length (μm) | width (μm) | sinking | number | papillae | cutinization |
| ndistinct<br>ongitudinal | 18 | 12 | below epidermis level | 4—6 | on all cells (Ø 10 μm) | weak |
| ndistinct | 14—18 | 10—12 | below epidermis level | 4—6 | on some cells | weak |
| ? | ? | ? | ?below epidermis level | ? | ? | ?very weak |
| rregular | ?<br>20—35 | ?<br>10—17 | very sunken | 4—6 | — | stronger |
| ndistinct | 24—28 | 16—20 | on epidermis level | 5—6 | — | weak |

| hairs and hair bases | | | | | papillae | |
|---|---|---|---|---|---|---|
| site of base occurrence hairs designated (H)] | number of cells forming a base | base diameter (μm) | hairs | | site of occurrence | diameter (μm) |
| | | | length (μm) | width (μm) | | |
| — | — | — | — | — | ad. cuticle<br>midvein<br>ab. cuticle | 40<br>10 |
| ad. cuticle<br>midvein | 1 | 20—25 | — | — | ab. cuticle | 10 |
| midvein (H)<br>?costal area | 1 | 45 | up to 500 | 70—95 | — | — |
| ab. cuticle<br>midvein | 1 | 12—15 | — | — | — | — |
| ad. cuticle (H)<br>midvein (H) | 1<br>2 | 80—100<br>70—90 | up to 320<br>up to 350 | 55—65<br>45—50 | ab. cuticle | up to 15 |

*moravica* has oriented longitudinally quadrangular cells with straight or gently bent anticlinal walls, *Alethopteris schneideri* has oriented, irregularly polygonal through rectangular cells with straight or gently bent anticlinal walls, *Alethopteris zeilleri* has unoriented, irregularly polygonal cells with undulated anticlinal walls.

### *Palaeoecology and palaeosociology*

The most abundant species of all Alethopterids comming from mines is *Alethopteris zeilleri* (Ragot) Wagner. In the Kladno Basin, the Mine Jiřina 2 at Libovice exhibited 77 % and Mine Magdalena at Kvílice 93 % of specimens of the genus *Alethopteris* Sternberg pertaining to the species *Alethopteris zeilleri*. This species occurs predominantly in the vicinity of seams. *Alethopteris zeilleri* is not connected with coal seams only in the Permian grey horizons in the Boskovice Furrow. *Alethopteris zeilleri* in the Stephainan B is accompanied by rich seam-forming flora; the following are the most important species according to Havlena (1964): *Annularia spicata* Gutb., *A. sphenophylloides* Zenker, *A. stellata* Schl., *Asterophyllites equisetiformis* Schl., *Sphenophyllum oblongifolium* Germ. et Kaulf., *S. longifolium* (Germ.) Gutb., *Sigillaria brardi* Stbg., *S. ichthyolepis* Bgt., *Asolanus camptotaenia* Wood, *Nemejcepteris feminaeformis* (Bgt.) Barthel, *Pecopteris arborescens* Schl., *P. lepidorachis* Kidst. et auct., *P. polymorpha* Bgt., *P. polypodioides* Stbg., *Dicksonites plückeneti* Schl., *Pseudomariopteris ribeyroni* (Zeill.) Corsin, *Odontopteris subcrenulata* Rost, *Mixoneura neuropteroides* (Goepp.) Zeill. and *Callipteridium trigonum* Franke.

In the Stephanian C *Alethopteris zeilleri* is accompanied by additional species which transgress into the Permian: *Calamites gigas* Bgt., *Pecopteris permica* Njc. and *Odontopteris osmundaeformis* (Schl.) Zeill.

In the Rosice-Oslavany group of seams from the Stephanian-Autunian boundary *Alethopteris zeilleri* is accompanied mainly by the following species (Němejc 1953): *Annularia stellata* Schl., *A. sphenophylloides* Zenker, *Asterophyllites equisetiformis* Schl., *Sphenophyllum oblongifolium* Germ. et Kaulf., *S. angustifolium* Germ., *S. emarginatum* Bgt., *Nemejcopteris feminaeformis* (Bgt.) Barthel, *Pecopteris polypodioides* Stbg., *P. permica* Njc., *P. hemitelioides* Bgt., *P. densifolia* Goepp., *P. candoleana* Bgt., *Alethopteris moravica* Augusta, *Linopteris germari* Giebel, *Odontopteris osmundaeformis* Schl., *O. minor* Bgt. and *Mixoneura auriculata* Bgt.

The species *Odontopteris subcrenulata* Rost, *Sphenopteris germanica* Weiss, *Lebachia piniformis* (Stbg.) Fl., *Ernestiodendron filiciforme* (Stbg.) Fl. and *Callipterids* [*Callipteris conferta* (Stbg.) Bgt. and *C. zbýšovensis* Augusta (Augusta 1946)] which occur in the overlying rock of the first (uppermost) seam are considered by Němejc (1953) as allochthonous elements.

In the Autunian of the Boskovice Furrow the species *Alethopteris zeilleri* is accompanied especially by the following species (revised after NĚMEJC 1953): *Calamites gigas* BGT., *Asterophyllites equisetiformis* SCHL., *A. longifolius* STBG., *A. dumasi* ZEILL., *Annularia stellata* SCHL., *A. sphenophylloides* ZENKER, *Nemejcopteris feminaeformis* (BGT.) BARTHEL, *Pecopteris hemitelioides* BGT., *P. arborescens* SCHL., *Mixoneura auriculata* BGT., *Odontopteris subcrenulata* ROST, *Taeniopteris multinervis* WEIS, *T. jejunata* GR. 'EURY, *Callipteris conferta* (STBG.) BGT., *C. lyratifolia* GOEPP., *C. naumanii* GUTB., *C. bergeroni* ZEILL., *Alethopteris schneideri* (STERZ.) STERZ., *Dicranophyllum galicum* GR. 'EURY, *Lebachia piniformis* (STBG.) FL. and *Ernestiodendron filiciforme* (STBG.) FL. According to HAVLENA - PEŠEK (1983) these species grew on the banks of episodic lakes. This flora assemblage is classified as middle Autunian.

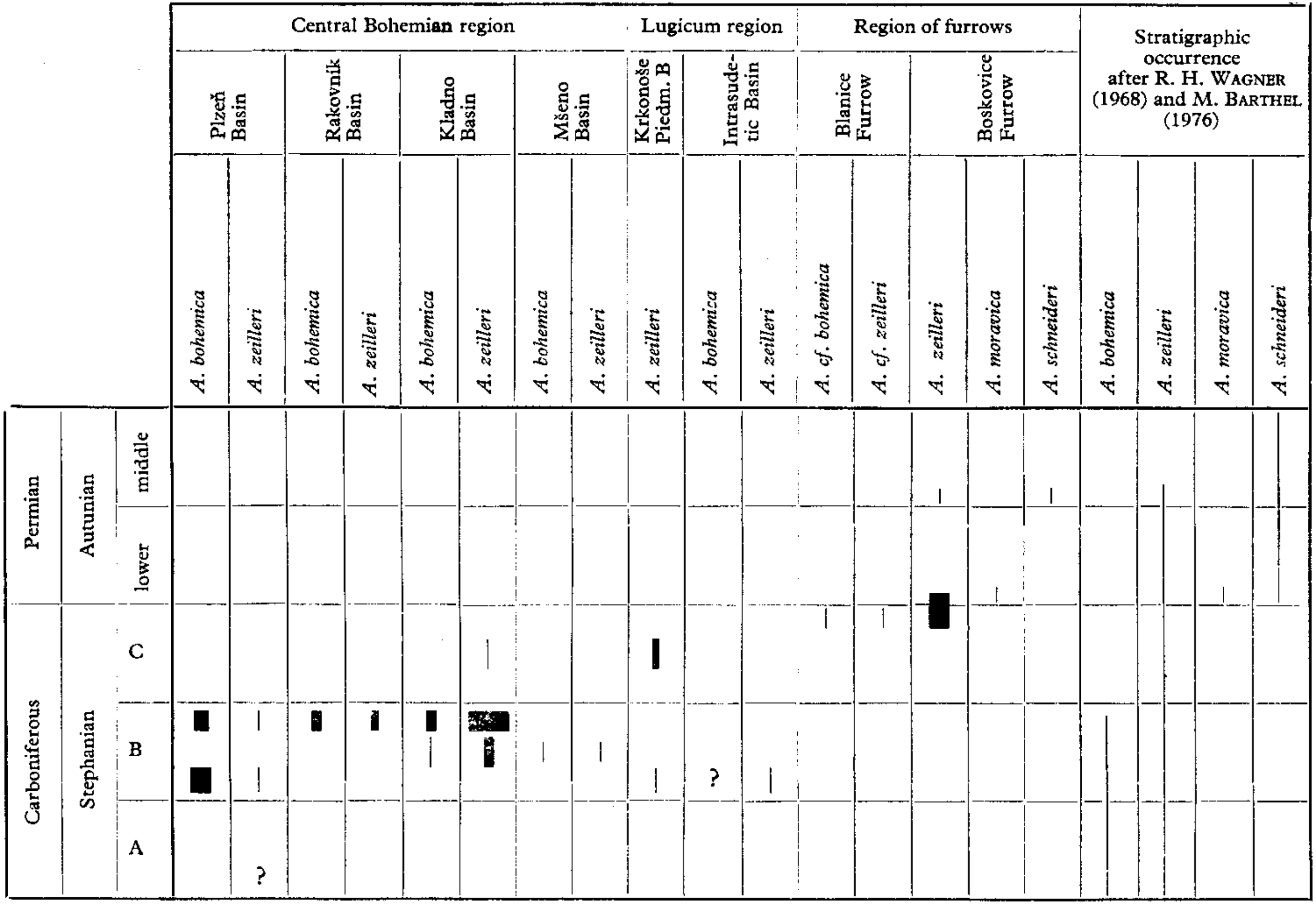
In contrast to *Alethopteris zeilleri* (RAGOT) WAGNER, the species *Alethopteris bohemica* FRANKE occurs in more coarse-grained rocks which are unfavourable for cuticle preservation. The mode of preservation and structure of cuticles (abaxial cuticle exhibits xeromorphic features) of this species corresponds to elements of the Stephanian extra-seam flora that probably grew on margins of coal--bearing basins. The following species are ranged with the extra-seam floral assemblage (HAVLENA 1964): *Linopteris germari* GIEBEL. *L. neuropteroides* (GUTB.) ZEILL. var. *minor* POT., *Callipteridum gigas* GUTB., *Ernestiodendron filiciforme* (SCHL.) FL. and a seed of *Samaropsis moravica* (HELMH.) SEW. *Alethopteris bohemica* can be sporadically found also on mine dumps as an allochthonous element. In these sites *Alethopteris bohemica* is accompanied by the same species as *Alethopteris zeilleri*. In Bohemia, *Alethopteris bohemica* is found solely in the Stephanian B. Two uncertain finds were reported from the Stephainan C of the Blanice Furrow.

There are known only three specimens of *Alethopteris moravica* AUGUSTA preserved in grey claystones accompanying the first (youngest) seam of the Rosice--Oslavany group of seams. Whether they represent a seam-forming or allochthonous element in the basin remains a question. However, *Alethopteris moravica* should be certainly considered a rare endemic species of the Boskovice Furrow. Its accompanying assemblage is given in the description of the Rosice-Oslavany group of seams, which occurs with *Alethopteris zeilleri* (RAGOT) WAGNER.

The ecologic-sociologic amplitude of *Alethopteris schneideri* (STERZEL) STERZEL is relatively wide according to BARTHEL (1976). It is abundant in open pioneer assemblages with very unquiet stationary conditions. The species is significant especially for the middle and upper parts of the Autunian. The accompanying assemblage is given in the description of the Autunian assemblage of *Alethopteris zeilleri* (RAGOT) WAGNER.

Table 2

Occurrence of the genus *Alethopteris* STERNBERG in the Stephanian and Permian of Bohemia and Moravia



Width of line denotes extent of occurrence (thin line — isolated occurrence), ? — uncertain or undocumented occurrence.


1


2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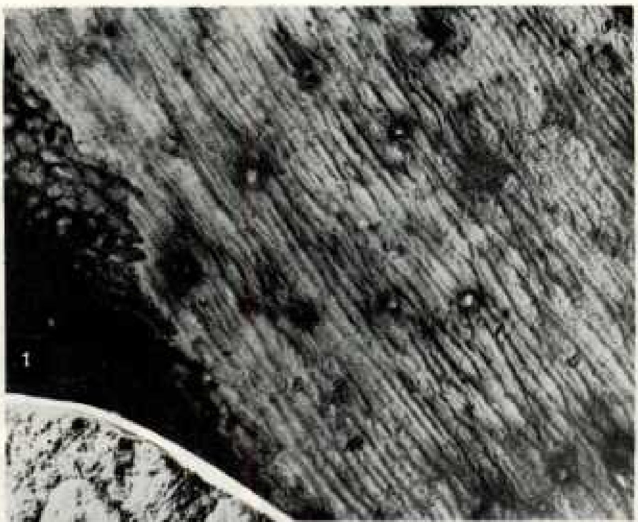
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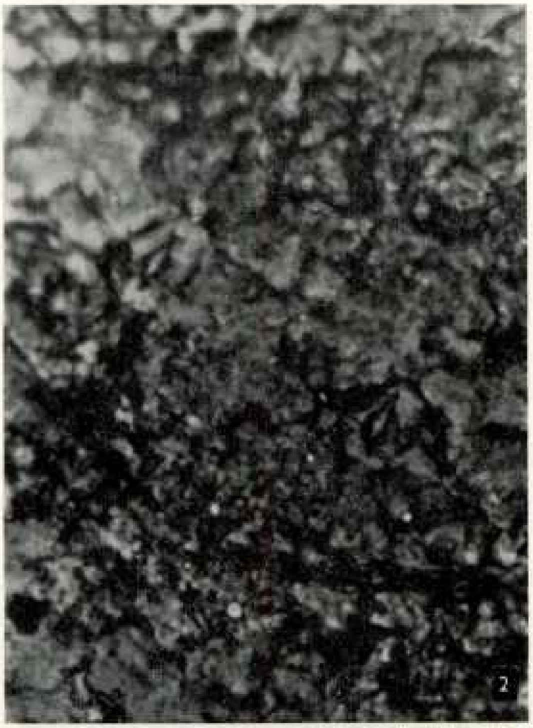
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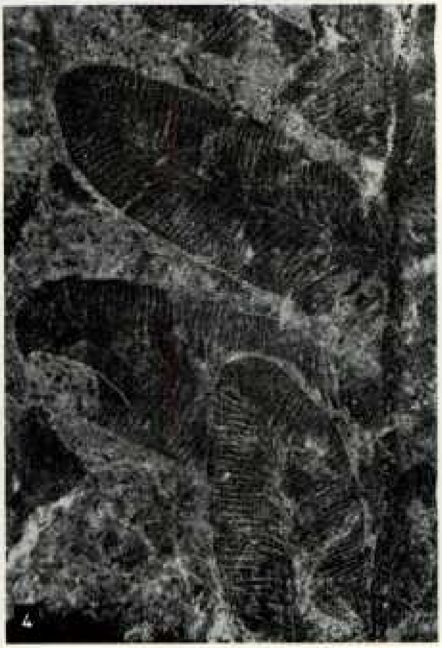
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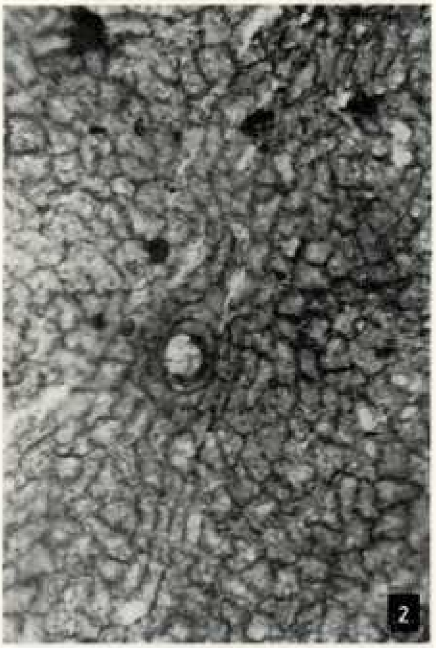
Pl. IV


1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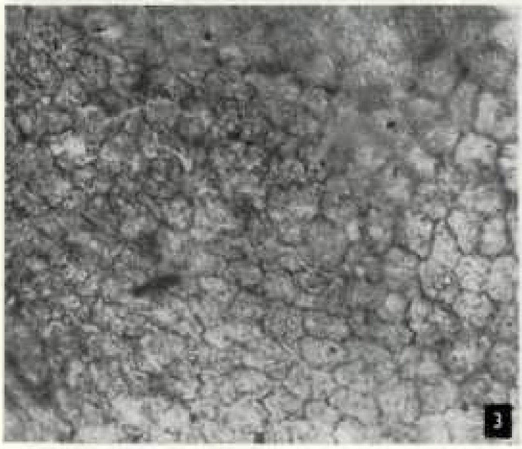
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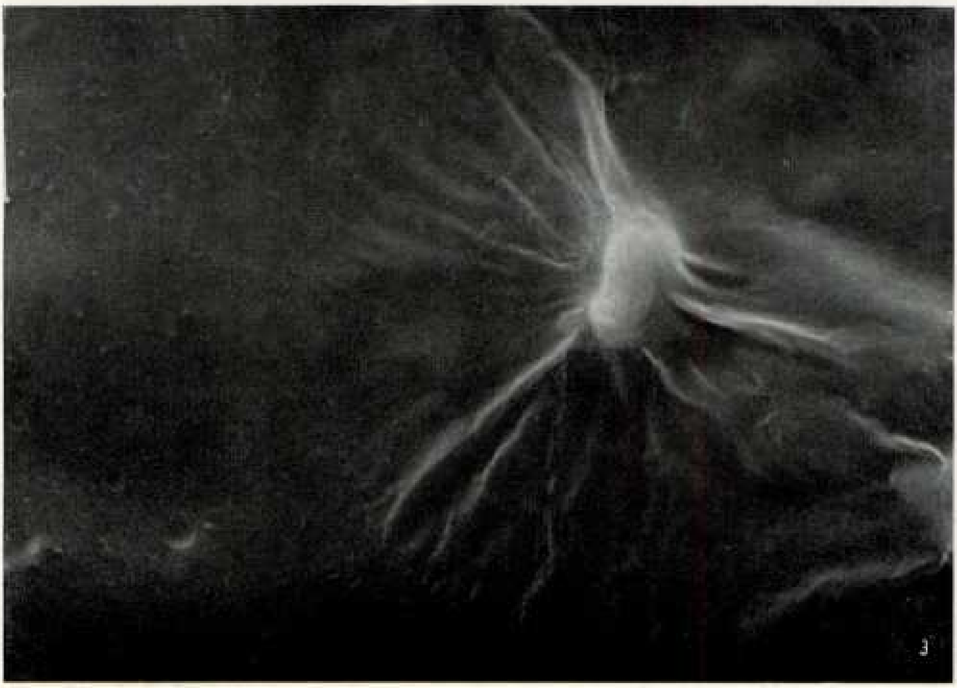
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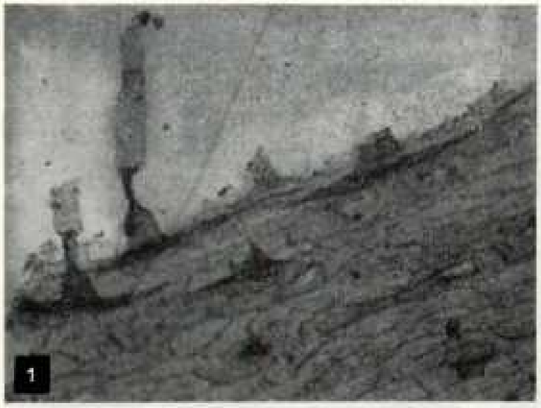
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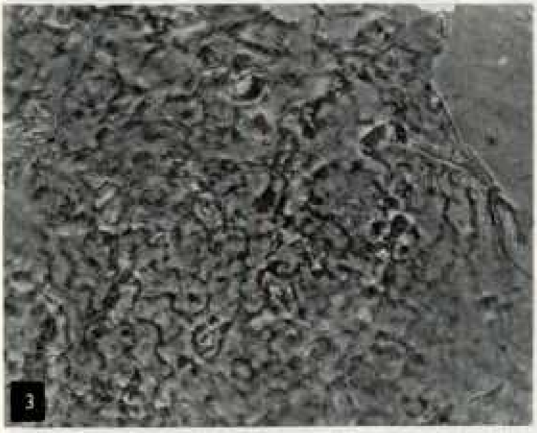
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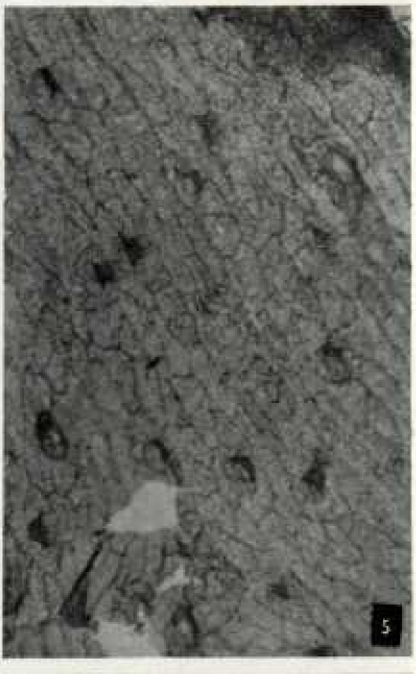
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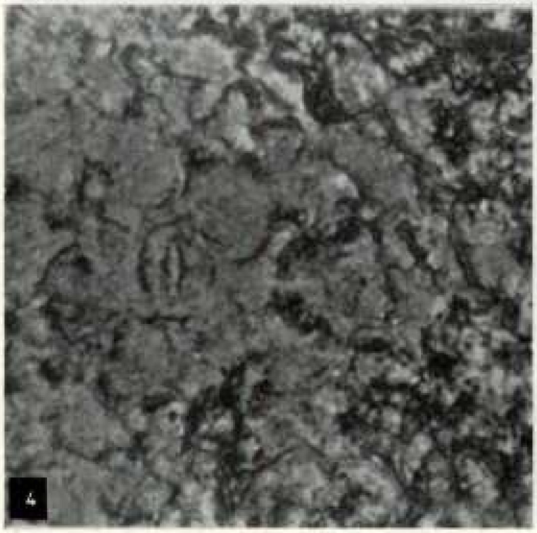
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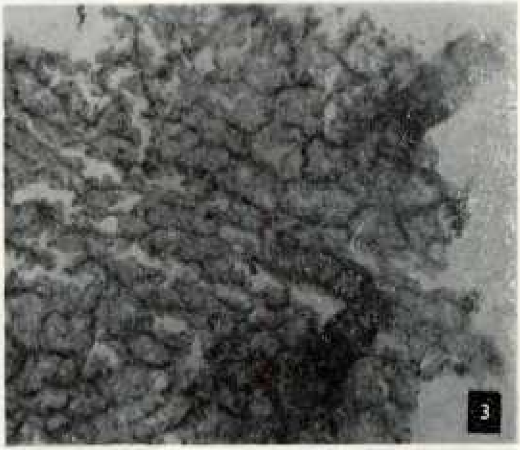
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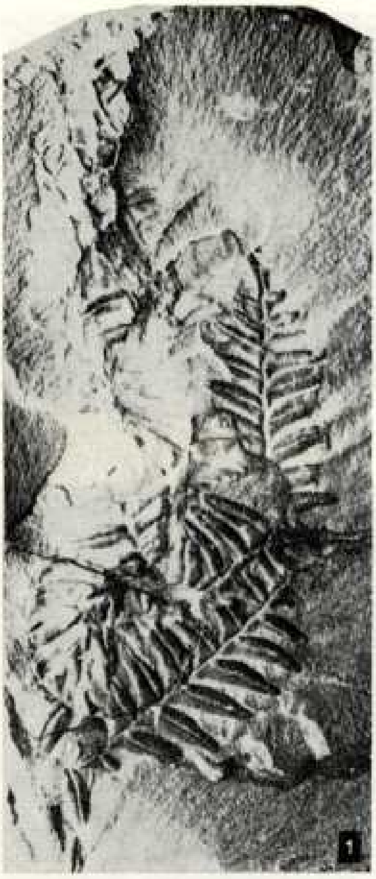
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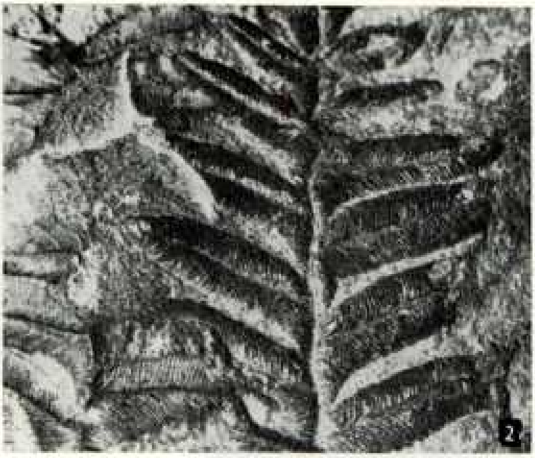
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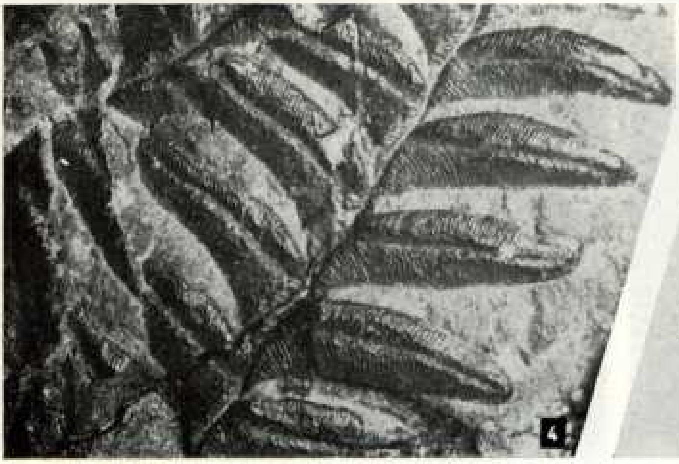
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Pl. X


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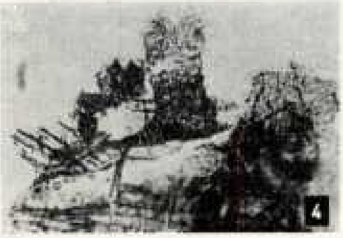
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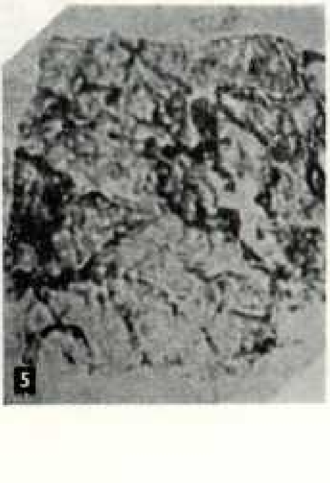
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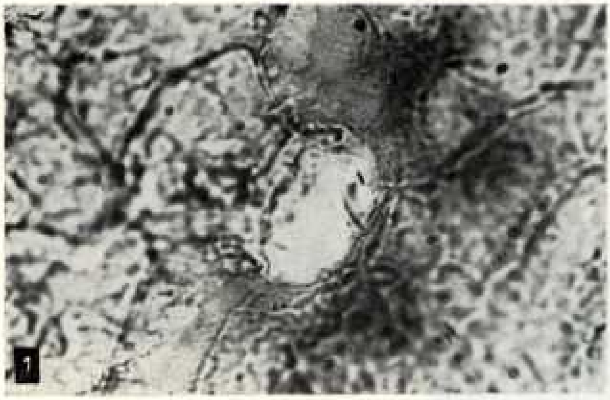
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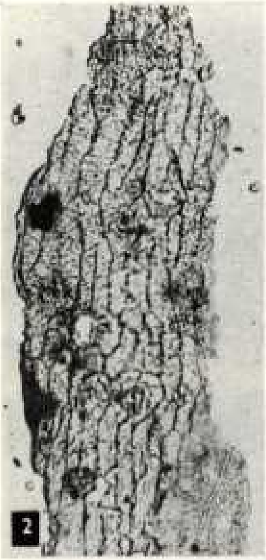
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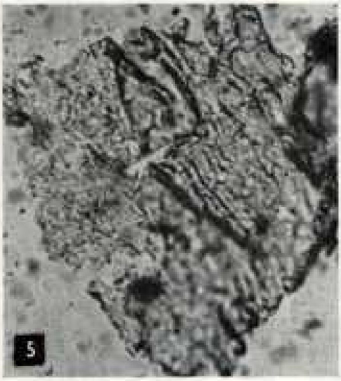
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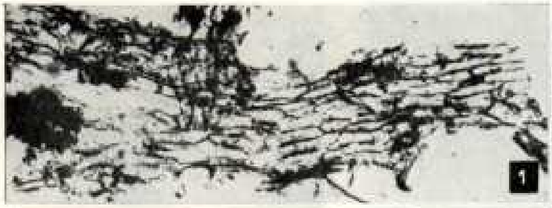
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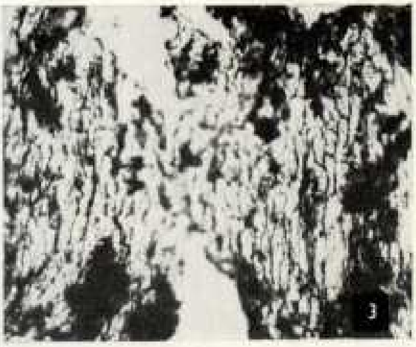
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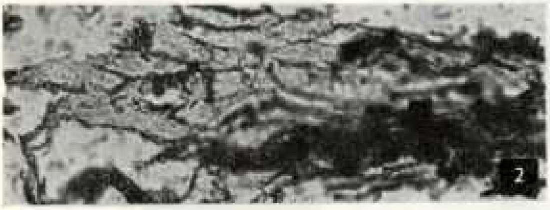
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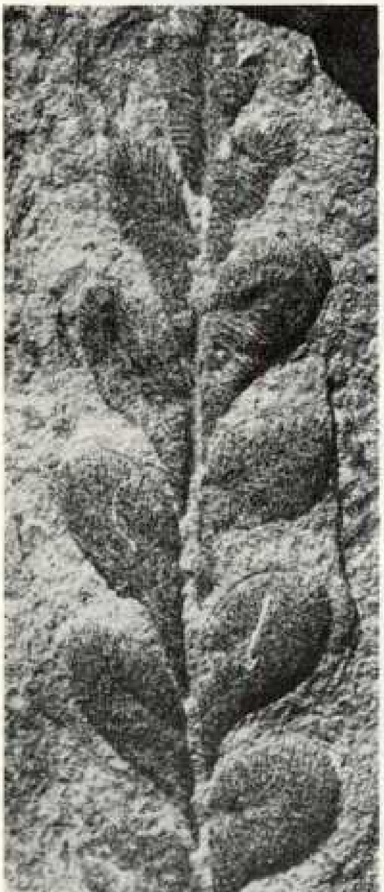
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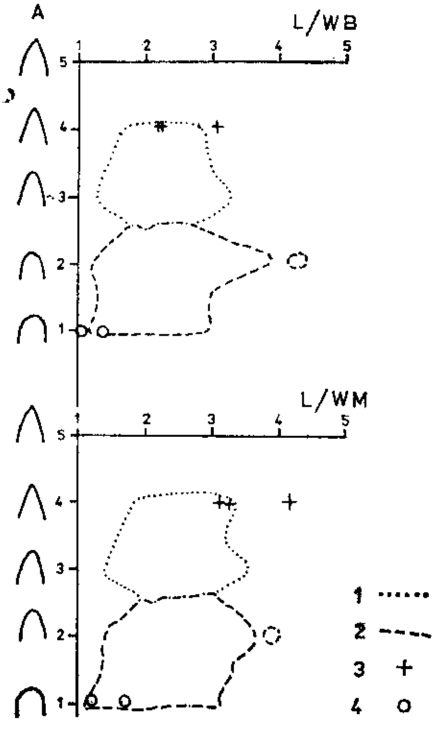
## *Remarks on stratigraphy*

Lithostratigraphic tables of the Intrasudetic Basin, Krkonoše Piedmont Basin and central Bohemian region were recently presented in the paper of Zajíc and Štamberg (1986). According to the present knowledge (Havlena-Pešek 1980), the Mělník group of seams in the Jelenice Member in central Bohemian region, Syřenov group of seams in the Krkonoše Piedmont Basin and Radvanice group of seams in the Intrasudetic Basin (Stephanian B) mutually correlate. The Kounov group of seams in central Bohemian region is younger (upper Stephanian B). The Klobuky horizon in central Bohemian region correlates with the upper Ploužnice horizon (also called the Štěpanice-Čikvásky horizon) in the Krkonoše Piedmont Basin (Stephanian C). In central Bohemian region in the Slaný Formation (Stephanian B) some authors unify Mšec and Hředle Members under Malesice Member and Ledce, Kounov and Kamenný Most Members under the name Otruby Member.

The lower two seams of the Rosice-Oslavany group of seams in the Boskovice Furrow are considered Stephanian but the uppermost seam (lst main) is ranged with the Autunian according to finds of the genus *Callipteris* Brongniart in the seam roof. Grey horizons in the main red-brown formation in the overlying rock of the Rosice-Oslavany group of seams are classified as middle Autunian (Havlena - Pešek 1983).

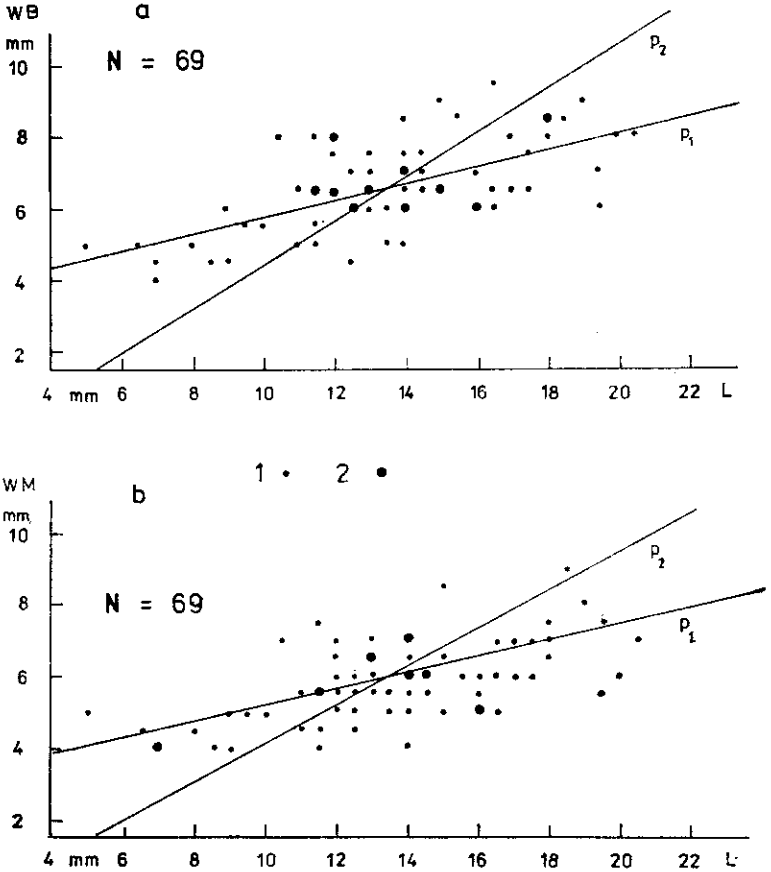


11. Relation between type of apex and pinnule length/width ratio
*A* – type of apex, *L/WB* – length/width of pinnules at base, *L/WM* – length/width of pinnules in the middle
*1* – *Alethopteris bohemica* Franke (69 specimens), *2* – *Alethopteris zeilleri* (Ragot) Wagner (166 specimens), *3* – *Alethopteris moravica* Augusta (3 specimens), *4* – *Alethopteris schneideri* (Sterzel) Sterzel (2 specimens)

## *Statistical evaluation of the material*

The studied samples of *Alethopteris bohemica* Franke and *Alethopteris zeilleri* (Ragot) Wagner were statistically measured to establish the range of shape variations of these species. The lenght of pinnules, pinnule width at the base and in the middle, number of veins per 1 cm of pinnule border was measured and the type of the pinnule apex determined.

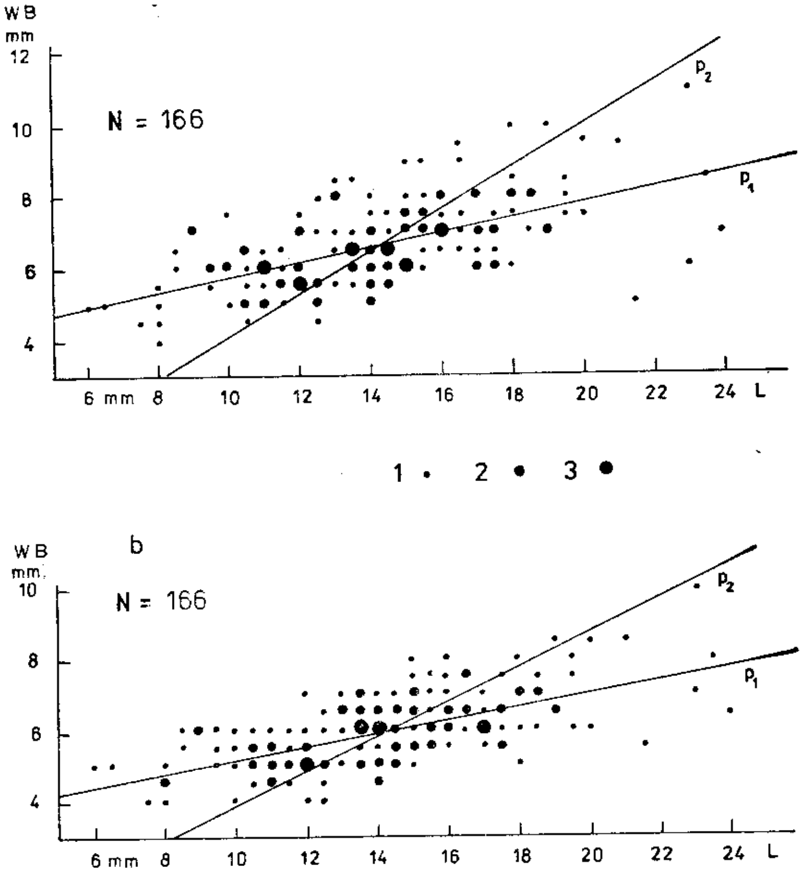
The measured data were used for plotting linear dependencies of the pinnule length and width at the base and in the middle and regression lines for *Aletho-*



12. Linear dependency of length and width of pinnules of *Alethopteris bohemica* Franke
*N* — number of specimens, *L* — length of pinnules, *WB* — width of pinnules at base, *WM* — width of pinnules in the middle; regression lines: $p_1$ — dependence of *WB* (*WM*) on *L*, $p_2$ — dependence of *L* on *WB* (*WM*); critical value of correlation index *r* on level $1 - a = 0.999$: 0.393, correlation index *r* for fig. *a* — 0.606, for fig. *b* — 0.585; *1* — 1 specimen, *2* — 2 to 3 specimens

*pteris bohemica* and *Alethopteris zeilleri* were drawn. For the regression lines were calculated correlation indexes. The calculated value of the correlation index (cca 0.6) always exceeds its critical value on the level $1 - \alpha = 0.999$. It indicates, roughly speaking, that there exists a correlation between the length and width of the pinnules.

Polygones of relative frequency of measured indexes were constructed: length of pinnules, width of pinnules at the base and in the middle and number of veins per 1 cm of pinnule border. The plotted points correspond with the number of samples in the given frequency class expressed in per cents. The plots have several



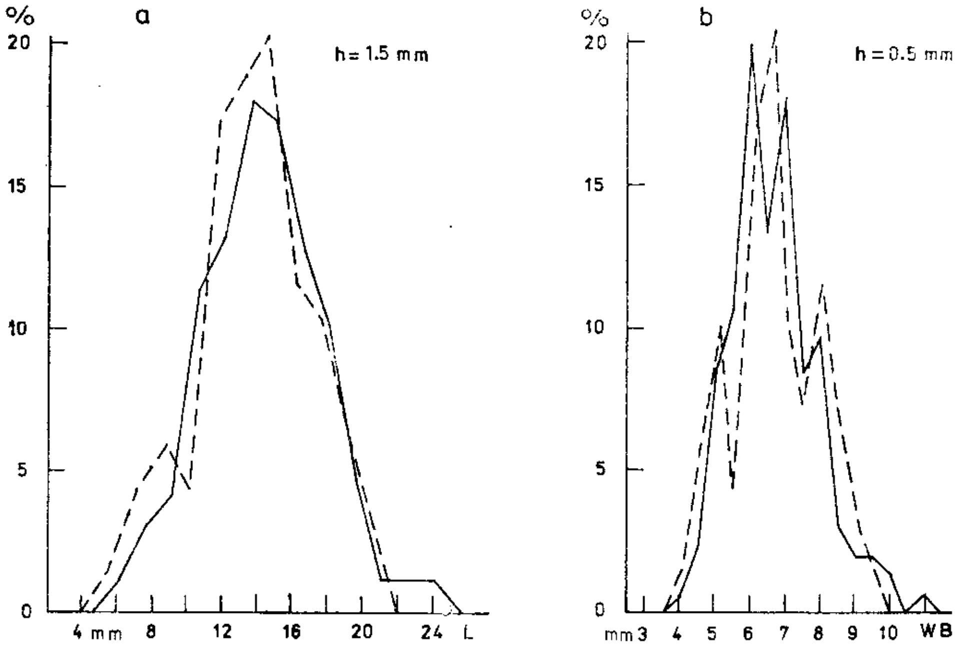
13. Linear dependency of length and width of pinnules of *Alethopteris zeilleri* (Ragot) Wagner
*N* – number of specimens, *L* – pinnule length, *WB* – width of pinnules at base, *WM* – width of pinnules in the middle; regression lines: $p_1$ – dependence of *WB* (*WM*) on L, $p_2$ – dependence of *L* on *WB* (*WM*); critical value of correlation index *r* on level $1 - \alpha = 0.999$: 0.294, correlation index *r* for fig. *a* – 0.589, for fig. *b* – 0.629; *1* – 1 specimen, *2* – 2 to 3 specimens, *3* – 4 to 5 specimens

Table 3

Some measured features of the described species of the genus *Alethopteris* STERNBERG

| | number of measured specimens N | length of pinnules (mm) | | width of pinnules at base (mm) | |
|---|---|---|---|---|---|
| | | arithmetical mean | devitaion | arithmetical mean | deviation |
| *A. bohemica* | 69 | 13.59 | ± 7 | 6.62 | ± 2.5 |
| *A. moravica* | 3 | 14.33 | ± 7 | 6.33 | ± 1 |
| *A. schneideri* | 2 | 6 | ± 1 | 5 | ± 0 |
| *A. zeilleri* | 166 | 14.25 | ± 8 | 6.65 | ± 2.5 |

apexes however the central apex is always the highest one and lower apexes are statistically insignificant (they originate due to small measuring inaccuracies in a relatively small statistical set). It follows from the plots that *Alethopteris bohemica* FRANKE and *Alethopteris zeilleri* (RAGOT) WAGNER cannot be distinguished from



14. Polygones of relative frequencies of length, width at base and in the middle and venation density in pinnules of the species *Alethopteris bohemica* FRANKE and *Alethopteris zeilleri* (RAGOT) WAGNER

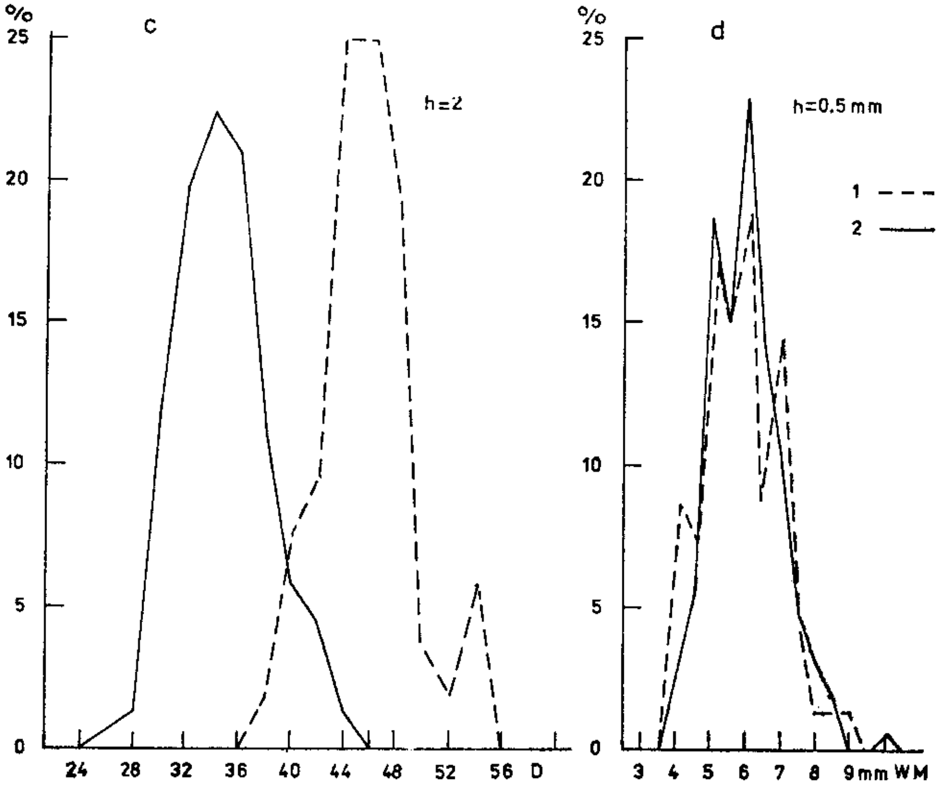
*L* — length of pinnules, *WB* — width of pinnules at base, *D* — number of veins per 1 cm of pinnule border, *WM* — width of pinnules in the middle, *h* — length of class, *1* — *Alethopteris bohemica* (figs. *a*, *b*, *d* of 69 specimens, fig. *c* of 52 specimens), *2* — *Alethopteris zeilleri* (figs. *a*, *b*, *d* of 166 specimens, fig. *c* of 152 specimens)

Table 3

| vidth of pinnules in the middle (mm) | | number of veins per 1 cm of pinnule border | | type of pinnule apex |
|---|---|---|---|---|
| arithmetical mean | deviation | arithmetical mean | deviation | |
| 5.83 | ±2.5 | 45.6 | ±8 | bluntly pointed |
| 4.66 | ±1.5 | 60 | ±5 | bluntly pointed |
| 4.25 | ±0.25 | 45 | ±3 | broadly rounded |
| 5.97 | ±2.5 | 34.7 | ±9 | broadly rounded |

each other on the basis of the pinnule length and width. Greater difference between the two species shows the plot "number of veins per 1 cm of pinnule border" (text-fig. 14c).

Relationship between the type of the pinnule apex and the length/width ratio



(at the base and in the middle) of the pinnules was calculated after the work of SCHEIHING and PFEFFERKORN (1980). On the basis of this relationship the species *Alethopteris bohemica* and *Alethopteris zeilleri* can be well distinguished according to different types of pinnule apexes. The plot (fig. 11) shows also 5 measured samples of the species *Alethopteris moravica* AUGUSTA and *Alethopteris schneideri* (STERZEL) STERZEL from the territory of Czechoslovakia.

## Conclusion

The Stephanian and Permian of Bohemia and Moravia exhibit 4 species of the genus *Alethopteris* STERNBERG: *Alethopteris bohemica* FRANKE, *Alethopteris moravica* AUGUSTA, *Alethopteris schneideri* (STERZEL) STERZEL and *Alethopteris zeilleri* (RAGOT) WAGNER. Specimens of *Alethopteris zeilleri* (RAGOT) WAGNER from various places of Czechoslovakia were long time described under the name *Alethopteris bohemica* FRANKE. *Alethopteris bohemica* together with *Alethopteris zeilleri* are widespread especialy in the basins of Central Bohemian region with Stephanian sediments. *Alethopteris bohemica* is most numerous in the Plzeň Basin. *Alethopteris bohemica* was not confirmed from the Intrasudetic Basin, and from the Blanice Furrow were reported specimens designated as *Alethopteris cf. bohemica* (pl. I, fig. 3). On the other hand, *Alethopteris zeilleri* is widespread in all regions with the Stephanian and Permian sediments. It is most abundant in the Kladno Basin and also very common in the Boskovice Furrow in the Rosice-Oslavany group of seams. Both species exhibit different morphologic features and cuticles. *Alethopteris bohemica* disappears by the end of the Stephanian, *Alethopteris zeilleri* transgresses into the Autunian. *Alethopteris bohemica* is an element of the extra-seam flora while *Alethopteris zeilleri* belongs to elements of the seam-forming flora. In the Permian, it occurs also in grey sediments accompanying the extra-seam flora. *Alethopteris schneideri* (STERZEL) STERZEL known solely from the Permian of the Boskovice Furrow on the Czechoslovak territory was found in similar sediments.

The species *Alethopteris moravica* AUGUSTA is very rare endemic species of the Rosice-Oslavany group of seams of the Boskovice Furrow. Holotype is complemented with another 2 findings and cuticles with hairs. Hairs were also established in *Alethopteris zeilleri* which exhibited mesomorphic features of cuticles.

Xeromorphic features on the abaxial cuticle (according to the structure of the stoma) were observed in *Alethopteris bohemica* and *Alethopteris schneideri*.

It follows from the statistical evaluation that the species *Alethopteris bohemica* and *Alethopteris zeilleri* can be differentiated in the plot showing the venation density and in the plot showing the dependence of the length/width ratio on the type of apex.

*K tisku doporučila E. Purkyňová*
*Přeložila T. Hlavatá*

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## Explanation of plates

All photographs besides those given below are made by the author. Photographs on pl. V by J. Kulich, on pl. XII, figs. 5, 6 by M. Barthel. Photographs were not retouched; all preparations for microphotographs are deposited in the Geological Survey, Prague.

### Pl. I

*Alethopteris bohemica* FRANKE

1. Pinnae of the last order, locality Radčice, digged test pit Š-80, Plzeň Basin, Stephanian B. Coll. J. Šetlík, Geological Survey, Prague, no. YA 1273, full size.
2. Terminal part of pinna of the last order, locality Radčice, digged test pit Š-80, Plzeň Basin, Stephanian B, Coll. J. Šetlík, Geological Survey, Prague, no. YA 1275, ×2.
3. *Alethopteris* cf. *bohemica*, pinna of the last order, locality Dolní Peklov near Kostelec nad Černými lesy, Blanice furrow, Stephanian C. Coll. F. Němejc, National Museum, Prague, full size.

4. Part of frond of the last order which served for preparation of cuticle preparates no. 127/1, 127/2 (cuticles in plates I and II), loc. borehole 8200/IV, depth 20.2 m, Stephanian. Coll. J. Šetlík, Geological Survey, Prague, no. YA 1276, ×2.
5. Abaxial cuticle with stomata, preparate no. 127/2 (impression on fig. 4), loc. borehole 8200/IV, depth 20.2 m, ×500.
6. Adaxial cuticle with hair base, preparate no. 127/2 (impression on fig. 4), loc. borehole 8200/IV, depth 20.2 m, ×200.

Pl. II

*Alethopteris bohemica* Franke (figs. 1–3)
*Alethopteris zeilleri* (Ragot) Wagner (figs. 4–7)

1. Abaxial cuticle in the site of pinnule midvein with hair bases, preparate no. 127/2 (impression on pl. I, fig. 4), loc. borehole 8200/IV, depth 20.2 m, ×100.
2. Hair base on adaxial cuticle, preparate no. 127/2 (impression pl. I, fig. 4), loc. borehole 8200/IV, depth 20.2 m, ×500.
3. Pinnules with characteristic venation, locality Libovice, Mine Jiřina 2, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. Z. Šimůnek, Geological Survey, Prague, no. YA 1283, ×3.

*Alethopteris zeilleri* (Ragot) Wagner

4. Small pinna of the last order, locality Kvílice, Mine Magdalena, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. K. Feistmantel, National Museum, Prague, no. 1643, full size.
5. Pinna of the last order, locality Kvílice, Mine Magdalena, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. K. Feistmantel, National Museum, Prague, no. E 5001, full size.
6. Isolated pinnules after maceration serving for preparation of cuticles no. 1/29–34, locality Libovice, Mine Jiřina 2, Kladno Basin, Kounov group of seams, upper Stephanian B, ×3.
7. Abaxial cuticle in the site of midvein, preparate no. 36/2 (impression pl. III, fig. 1), locality Kvílice, Mine Magdalena, Stephanian B, ×100.

Pl. III

*Alethopteris zeilleri* (Ragot) Wagner

1. Pinna of the last order which served for preparation of cuticles no. 36/1–18 (cuticles on pl. II, IV, VI), locality Kvílice, Mine Magdalena, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. K. Feistmantel. National Museum, Prague, ×2.
2. Abaxial cuticle with stomata, preparate no. 36/25 (impression not figured), locality Libovice, Mine Jiřina 2, Stephanian B, ×500.
3. Terminal part of pinna of the last order, locality Kvílice, Mine Magdalena, Kladno Basin, upper Stephanian B. Coll. K. Feistmantel, National Museum, Prague, ×3.
4. Fragment of pinna of the last order with pinnules showing more dense venation than that of typical pinnules, locality Libovice, Mine Jiřina 2, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. Z. Šimůnek, Geological Survey, Prague, no. YA 1277, ×3.

Pl. IV

*Alethopteris zeilleri* (Ragot) Wagner

1. Adaxial cuticle, preparate no. 1/12 (impression not figured), locality Libovice, Mine Jiřina 2, Stephanian B, ×200.
2. Adaxial cuticle with hair base, preparate no. 1/34 (impression on pl. II, fig. 6), locality Libovice, Mine Jiřina 2, Stephanian B, ×100.
3. Adaxial cuticle, preparate no. 36/39 (impression not figured), locality Kvílice, Mine Magdalena, Stephanian B, ×100.

4. Adaxial cuticle, preparate no. 36/3 (impression on pl. III, fig. 1), locality Kvílice, Mine Magdalena, Stephanian B, × 100.

Pl. V

*Alethopteris zeilleri* (RAGOT) WAGNER

1. Adaxial cuticle with gently furrowed and bumpy periclinal walls, locality Libovice, Mine Jiřina 2, Stephanian B, × 500.
2. Detail from fig. 1, × 5000.
3. Abaxial cuticle with papilla, locality Libovice, Mine Jiřina 2, Stephanian B, × 1000.
   (SEM photomicrographs of cuticles, photo J. Kulich)

Pl. VI

*Alethopteris zeilleri* (RAGOT) WAGNER

1. Abaxial cuticle in site of midvein with hairs, preparate no. 1/30 (pinnules on pl. II, fig. 5), locality Libovice, Mine Jiřina 2, Stephanian B, × 100.
2. Hair base on abaxial cuticle in site of midvein, preparate no. 36/9 (impression on pl. III, fig. 1), locality Kvílice, Mine Magdalena, Stephanian B, × 500.
3. Abaxial cuticle with stomata, preparate no. 36/25 (impression not figured), locality Libovice, Mine Jiřina 2, Stephanian B, × 200.
4. Abaxial cuticles with stoma, preparate no. 36/9 (impression on pl. III, fig. 1), locality Kvílice, Mine Magdalena, Stephanian B, × 500.
5. Abaxial cuticle in site of midvein with numerous hair bases, preparate no. 36/2 (impression on pl. III, fig. 1), locality Kvílice, Mine Magdalena, Stephanian B, × 100.
6. Adaxial cuticle, preparate no. 36/45 (impression on pl. VIII, fig. 8), locality Oslavany, Mine Kukla, Stephanian C – Autunian, × 200.

Pl. VII

*Alethopteris zeilleri* (RAGOT) WAGNER

1. Pinna of the last order, locality Libovice, Mine Jiřina 2, Kladno Basin, Kounov group of seams, upper Stephanian B. Coll. Z. Šimůnek, Geological Survey, Prague, no. YA 1278, × 2.
2. Hair on adaxial cuticle (detail from fig. 3), locality Libovice, Mine Jiřina 2, Stephanian B, × 200.
3. Hairs on adaxial cuticle, preparate no. 1/34 (impression on pl. II, fig. 6), locality Libovice, Mine Jiřina 2, Stephanian B, × 100.
4. Pinna of the last order, locality Nedvězí, Krkonoše Piedmont Basin, Stephanian C. Coll. V. Havlena, Faculty of Science, Charles University, Prague, full size.
5. Terminal part of pinna of the last order, locality Zbýšov, Mine Antonín, Boskovice Furrow, Rosice-Oslavany group of seams, Stephanian C – Autunian. Coll. J. Šetlík - Z. Špinar, Geological Survey, Prague, no. YA 1279 white-coated, full size.
6. Pinna of the last order, locality Chvaleč, borehole Chv-3, depth 345.5 m, Intrasudetic Basin, Jívka Member, Stephanian B. Coll. E. Purkyňová, Silesian Museum, Opava, Acc. cat. 1/82, inv. no. F-3581a, white-coated, × 2.

Pl. VIII

*Alethopteris zeilleri* (RAGOT) WAGNER

1. Pinna of the last order, locality Babice near Zastávka, Mine Ferdinand, Boskovice furrow, Rosice-Oslavany group of seams, Stephanian C – Autunian. Coll. F. Němejc. National Museum, Prague, full size.
2. Terminal part of pinna of the last order, locality Zbýšov, Boskovice furrow, Autunian. Coll. Moravian Museum, Brno, acc. no. 68, × 2.

3. Fragment of pinna of the last order, locality Zbýšov, Boskovice furrow, Autunian, Coll. Moravian Museum, Brno, acc. no. 68, ×2.
4. Pinna of the last order which served for cuticle preparate no. 36/45 (pl. VI, fig. 6), locality Oslavany, Mine Kukla, Boskovice furrow, Rosice-Oslavany group of seams, Stephanian C – Autunian. Coll. F. Němejc, National Museum, Prague, no. 25980, full size.
5. Terminal part of pinna of the last order, locality Nedvězí, Stephanian C, Krkonoše Piedmont Basin. Coll. V. Havlena, Faculty of Science, Charles University, Prague, full size.

Pl. IX

*Alethopteris moravica* Augusta

1. Pinna of the last order (holotype) – served for cuticle preparations no. 140/1 and 140/2 (on pls. X and XI), locality Zastávka near Rosice, Mine Julius, 1. (main) seam, Boskovice furrow, Rosice-Oslavany group of seams, lowermost Autunian. Coll. J. Augusta, Faculty of Science, Jan Evangelista Purkyně University, Brno, inv. no. E 3961, full size.
2. Detail of pinnules of terminal part of pinna from fig. 1, ×3.
3. Pinna of the last order, locality Zastávka near Rosice, Boskovice Furrow, Rosice-Oslavany group of seams, lowermost Autunian. Coll. J. Augusta, National Museum, Prague, full size.
4. Detail of pinna of the last order from fig. 1.
5. Adaxial cuticle, preparate no. 139/3 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.

Pl. X

*Alethopteris moravica* Augusta

1. Fragment of pinna of the last order which served for cuticle preparates nos. 139/1 – 3 (cuticles on pls. IX, X, XI and XII), locality Zastávka near Rosice, Mine Julius, Boskovice Furrow, Rosice-Oslavany group of seams, lowermost Autunian. Coll. J. Augusta, Faculty of Science, Jan Evangelista Purkyně University, Brno, inv. no. 4604, full size.
2. Detail from fig. 1, ×3.
3. Detail from fig. 1, ×3.
4. Hair on adaxial cuticle, preparate no. 139/2 (impression on fig. 1), Zastávka near Rosice, Mine Julius, Autunian, ×100.
5. Abaxial cuticle, preparate no. 139/3 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×200.
6. Ditto, ×500.

Pl. XI

*Alethopteris moravica* Augusta

1. Hair base on abaxial cuticle in site of midvein, preparate no. 140/1 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×500.
2. Abaxial cuticle in site of midvein, preparate no. 140/1 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.
3. Adaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×200.
4. Adaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.
5. Abaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×200.
6. Hair, preparate no. 139/1 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.
7. Hair on cuticle in site of midvein, preparate no. 139/2 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.

8. Hair on adaxial cuticle, preparate no. 139/3 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×200.

Pl. XII

*Alethopteris moravica* AUGUSTA (figs. 1–4)
*Alethopteris schneideri* (STERZEL) STERZEL (figs. 5–6)

1. Adaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.
2. Adaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka, Mine Julius, Autunian, ×200.
3. Adaxial cuticle, preparate no. 139/2 (impression on pl. X, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.
4. Adaxial cuticle, preparate no. 140/2 (impression on pl. IX, fig. 1), locality Zastávka near Rosice, Mine Julius, Autunian, ×100.

*Alethopteris schneideri* (STERZEL) STERZEL

5. Frond of the last order, locality Moravský Krumlov, Boskovice furrow, Autunian, Coll. Moravian Museum, Brno, photo M. Barthel, ×4.
6. Frond of the last order, locality Zbýšov, Boskovice furrow, Autunian. Coll. Moravian Museum, Brno, acc. no. 68, photo M. Barthel, ×5.

# Alethopteridy stefanu a permu Čech a Moravy

*(Résumé anglického textu)*

Zbyněk Šimůnek

Předloženo 30. června 1986

Ve stefanu a permu Čech a Moravy se vyskytují 4 druhy rodu *Alethopteris* Sternberg: *Alethopteris bohemica* Franke, *Alethopteris moravica* Augusta, *Alethopteris schneideri* (Sterzel) Sterzel a *Alethopteris zeilleri* (Ragot) Wagner.

Pod jménem *Alethopteris bohemica* Franke byly dlouhou dobu popisovány ukázky *Alethopteris zeilleri* (Ragot) Wagner z různých míst ČSSR. *Alethopteris bohemica* spolu s *Alethopteris zeilleri* je rozšířena hlavně v pánvích středočeské oblasti se stefanskou výplní, a to nejvíce v plzeňské pánvi. Ve vnitrosudetské pánvi není doložena a z blanické brázdy jsou známy ukázky označené jako *Alethopteris* cf. *bohemica* (tab. 1, obr. 3). Naproti tomu *Alethopteris zeilleri* je rozšířena ve všech oblastech výskytu stefanu a permu. Nejhojnější je v kladenské pánvi, velmi hojná je rovněž v boskovické brázdě v rosicko-oslavanském souslojí. Oba druhy se liší morfologickými znaky i kutikulami. *Alethopteris bohemica* mizí koncem stefanu, *Alethopteris zeilleri* přechází do autunu. *Alethopteris bohemica* patří mezi prvky mimoslojové flóry, *Alethopteris zeilleri* mezi prvky slojotvorné květeny. V permu se však nachází také v šedých sedimentech ve společnosti mimoslojových rostlin. V podobných sedimentech se objevuje i *Alethopteris schneideri* (Sterzel) Sterzel, známá v ČSSR pouze z permu boskovické brázdy.

Druh *Alethopteris moravica* Augusta je velmi vzácný, endemický druh rosicko-oslavanského souslojí boskovické brázdy. Holotyp doplňují další 2 nálezy a kutikuly, na kterých byly zjištěny trichomy. Trichomy byly zjištěny také u *Alethopteris zeilleri*, která má mezomorfní znaky kutikul.

Xeromorfní znaky na spodní kutikule (podle stavby průduchů) jsou u druhů *Alethopteris bohemica* a *Alethopteris schneideri*.

Ze statistického zpracování vyplývá, že druhy *Alethopteris bohemica* a *Alethopteris zeilleri* můžeme rozlišit v grafu s hustotou žilnatiny a v závislosti poměru délky a šířky lístků na typu vrcholu.

## Алетоптеридные стефанского яруса и пермской системы Чехии и Моравии

Ревизией находок в Чехии и Моравии доказано присутствие 4 видов рода *Alethopteris* Sternberg, именно: *A. bohemica* Franke, *A. moravica* Augusta, *A. schneideri* (Sterzel) Sterzel и *A. zeilleri* (RAGOT) WAGNER. Их характеристики были дополнены описанием строения кутикул, изменяемости листков, обработанной систематически у видов *A. bohemica* и *A. zeilleri*. *A. schneideri* доказана в перми на территории ЧССР в первый раз.

Некоторые окаменелости из стефана и перми ЧССР, которые раньше считались представителями рода *Alethopteris*, относятся к другим родам или же видам, именно: *A. costei* ZEILLER (PURKYNĚ, 1929b, табл. 1, рис. 1) относится к виду *Praecallipteridium jongmansii* (P. BERTR.) WAGNER (WAGNER, 1963), *A. neessii* (GOEPP.) PRESL in STBG. — к роду *Callipteris* BGT. (FRANKE, 1912), *A. pteroides* (BGT.) GEIN. (FEISTMANTEL O., 1885, табл. 2, рис. 2—4) — к *Pecopteris polymorpha* BGT. (NĚMEJC, 1934), *A. punctata* AUGUSTA (AUGUSTA, 1927, табл. 1, рис. 2, табл. 2, рис. 1, 2) является, вероятно, видом *Pecopteris* (*Scolecopteris*) *pseudobucklandii* (ANDRAE in GERMAR) STUR (BARTHEL, 1981, стр. 923).

*Přeložil A. Kříž*

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| Sbor.<br>geol. věd | Paleontologie<br>30 | Seiten<br>159–173 | 4<br>Abb. | –<br>Tab. | 4<br>Taf. | Praha 1989<br>ISSN 0036-5297 |

# Biometrie und Morphologie der Samen von Stratiotes kaltennordheimensis und S. tuberculatus aus dem mitteleuropäischen Neogen

## Biometrie a morfologie semen druhů Stratiotes kaltennordheimensis a S. tuberculatus ze středoevropského neogénu

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Vorgelegt am 6. Oktober 1986

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Auszug: Ausgehend von der Studie von Holý und Bůžek (1966), die bei untermiozänen Funden von *Stratiotes kaltennordheimensis* Vergrößerungen der Samen in Abhängigkeit vom Zeitfaktor feststellen konnten, werden in diesem Aufsatz Funde der Gattung *Stratiotes* L. aus dem Untermiozän von Kaltennordheim, dem Mittelmiozän von Salzhausen, dem Obermiozän von Bernartice sowie aus dem Pannon und Pont des Wiener Beckens untersucht. Die Beziehungen von *Stratiotes kaltennordheimensis* zu Funden aus dem Pannon und Pont, die als *S. tuberculatus* bezeichnet werden, sowie die Frage der Artselbständigkeit von *S. tuberculatus* werden erörtert.

### Einleitung

Holý und Bůžek (1966) beschäftigten sich ausführlich mit variationsstatistischen Untersuchungen von *Stratiotes kaltennordheimensis* (Zenk.) Keilh. aus den untermiozänen Schichten des Kohlenbeckens von Chomutov–Most–Teplice. Sie verfolgten bei dieser Art alle morphologischen Merkmale (Länge, Breite, Länge : : Breite, Verlauf der Raphe, Stellung des Hilums, Orientierung der Mikropyle). Sie stellten dabei fest, daß sich diese Merkmale bei den Funden aus den unteren und oberen Lagen der flözführenden Schichtenfolge ändern, und daß diese Veränderungen gegebenenfalls auch stratigraphisch bedingt sein könnten, wobei allerdings auch andere Umstände eine Rolle gespielt haben konnten. Sie nehmen an, daß *S. kaltennordheimensis* im Pannon und Pliozän nicht mehr vorkommt – Funde aus dem Pannon des Wiener Beckens bestimmten sie als *Stratiotes tuberculatus* Reid – also als eine Art, die Kirchheimer (1957) für synonymisch zu *S. kaltennordheimensis* hält.

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Palamarev (1979) beschäftigte sich eingehend mit den Funden der Gattung *Stratiotes* im Tertiär Eurasiens, insbesondere in der Tertiärflora von Bulgarien, aus der er 8 Arten mit einer unterschiedlichen stratigraphischen Reichweite und unterschiedlichen morphologischen Merkmalen erwähnt. Er hält an der Selbständigkeit von *Stratiotes tuberculatus* Reid fest und definiert bei dieser Art zwei Unterarten. Nach seiner Ansicht kommen im Obermiozän *S. kaltennordheimensis* und *S. tuberculatus* nebeneinander vor.

Der Verfasser beschäftigte sich mit Samen der Gattung *Stratiotes* aus dem mährischen und slowakischen Sarmat, Pannon und Pont. Dabei ergab sich die Frage, ob in diesen Ablagenrungen neben *S. kaltennordheimensis* auch *S. tuberculatus* vorkommt, ob die Selbständigkeit der Art *S. tuberculatus* berechtigt ist, und wie sich variationsstatistisch verfolgbare Merkmale bei *S. kaltennordheimensis* in verschiedenaltrigen miozänen Schichten zueinander verhalten. Sinn dieses Aufsatzes ist es, weiteres Dokumentationsmaterial zu präsentieren, das die aufgeworfene Diskussion erweitern könnte.

Für diese Untersuchungen stand Material aus der Bohrung Bernartice U-58 bei Javorník in Nordmähren und aus zahlreichen Bohrungen, die im Pannon (Zone B) und im Pont (Pannon, Zone F) des Wiener Beckens und der Donauebene abgeteuft wurden, zur Verfügung. Weiter wurde Material vom Locus typicus von *S. kaltennordheimensis*, aus Kaltennordheim, sowie aus Salzhausen untersucht. Das Material aus Kaltennordheim und Salzhausen stammt aus den Sammlungen des Museums für Naturkunde in Berlin. Für die beretwillige Ausleihe ist der Verfasser Herrn Dr. H. Jähnichen zu aufrichtigem Dank verpflichtet. Weiter dankt er seinem langjährigen Freunde Herrn DrSc. Dieter H. Mai (Museum für Naturkunde, Berlin) für einige weiterführende Gedanken und Herrn Dr. Č. Bůžek, CSc. (Ústřední ústav geologický, Praha) für die Ausleihe der ursprünglichen graphischen Unterlagen zur Arbeit Holý - Bůžek (1966).

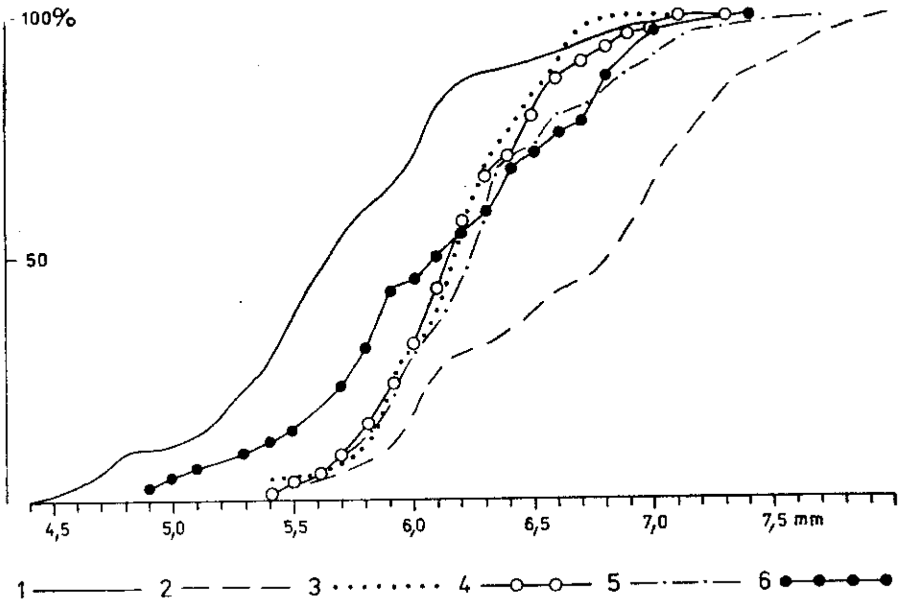
Hinsichtlich der stratigraphischen Stellung der behandelten Fundpunkte sei erwähnt, daß die Flora von Bernartice in das Ober-Baden bis Sarmat gestellt wird (Konzalová 1980, Knobloch 1982) und das pannonische bis pontische Alter der diesbezüglichen Schichten im Wiener Becken und in der Donauebene durch Ostrakoden oder Mollusken belegt oder durch die stratigraphische Lage im Hangenden des Sarmats gegeben ist. Kaltennordheim wird in das Burdigal, vielmehr Eggenburg gestellt (Müller-Stoll 1936). Bei Salzhausen ist die stratigraphische Stellung weniger klar. Meistens wird die Fundstelle in das Obermiozän gestellt. Mai (1964) parallelisiert sie mit der Cypris-Schichtenfolge im Cheb-Becken (Ottnang bis Karpat). Die Anwesenheit der Mastixioideen und anderer thermophiler Pflanzen macht ein Alter in der Zeitspanne Karpat bis Baden wahrscheinlich.

## Biometrie

Bei den Vermessungen wurde von der Prämisse ausgegangen, daß die Funde von einer Fundstelle oder aus gleichaltrigen Schichten zu einer Art gehören. Dies könnte sich negativ vor allem bei den Funden aus dem Pannon bis Pont ausgewirkt haben, bei denen es nicht eindeutig nachweisbar ist, ob manche Exemplare außer *Stratiotes tuberculatus* doch nicht eher zu *S. kaltennordheimensis* zu stellen sind. Aber da diese Funde mengenmäßig den mathematischen Vorbedingungen nicht entsprechen, war es schwierig, sich mit diesem negativen Faktor auseinanderzusetzen. Ein größerer Wert kommt daher eher der Diskussion der verschiedenen morphologischen Merkmale als der bloßen Gegenüberstellung der mathematischen Kurven zu, die lediglich als bestimmtes Dokumentationsmaterial angesehen werden sollten.

### *Längen-Index* (Abb. 1)

Es ist zweifellos interessant, daß es Holý - Bůžek (1966) möglich war, bei den Samen von *Stratiotes kaltennordheimensis* zwischen den Funden aus dem unteren

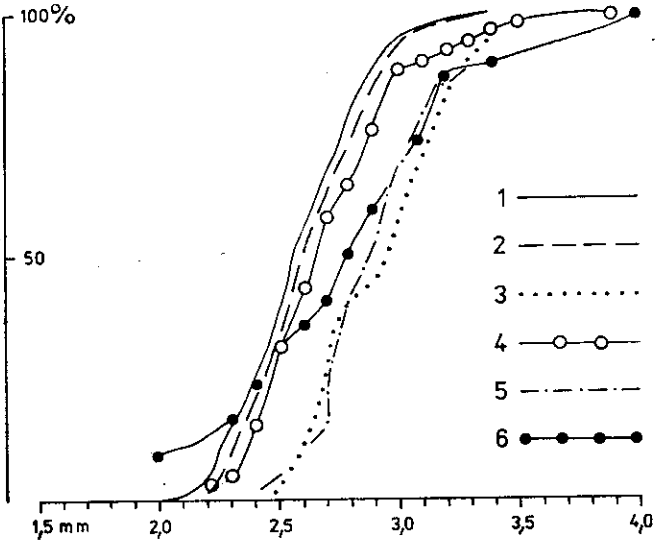


1. Die Längen-Werte der vermessenen *Stratiotes*-Samen aus dem mitteleuropäischen Neogen
*1* — untere Lage der flözführenden Schichtenfolge im nordböhmischen Kohlenbecken (nach F. Holý - Č. Bůžek 1966); *2* — obere Lage der flözführenden Schichtenfolge im nordböhmischen Kohlenbecken (nach F. Holý - Č. Bůžek 1966); *3* — Kaltennordheim, Untermiozän; *4* — Salzhausen, Mittelmiozän; *5* — Bernartice, Ober-Baden bis Sarmat; *6* — verschiedene Fundstellen im Pannon und Pont des Wiener Beckens

Teil gegenüber dem oberen Teil der flözführenden Schichtenfolge im nordböhmischen Kohlenbecken vor allem bei der Vermessung des Längen-Indexes große Unterschiede zu verzeichnen. Dabei handelt es sich um eine relativ kurze Zeitspanne, die durch diese Fossilien belegt ist. Im gleichen Sinne soll nun geprüft werden, wie sich die Funde aus ungefähr gleichaltrigen und jüngeren Schichten aus anderen Sedimentationsräumen verhalten. Da die Vermessung des Breiten-Indexes mehr oder minder verzerrte Werte liefert (Möglichkeit einer sekundären Deformation!), kommt dem Längen-Index besonders großer Wert zu. Die Anpassung unserer Messungen an die von Holý und Bůžek (1966) veröffentlichten Kurven des Längen-Wertes führte zu einem verblüffenden Ergebnis, da alle Kurven unserer Messungen von Samen der Gattung *Stratiotes* von stratigraphisch gleichaltrigen und jüngeren Fundstellen zwischen die Kurven, die anhand der Samen aus der unteren und oberen flözführenden Schichtenfolge des nordwestböhmischen Untermiozäns konstruiert wurden, zu liegen kamen (vgl. Abb. 1).

### *Breiten-Index* (Abb. 2)

Andere Verhältnisse treffen wir bei dem Breiten-Index an. Während die Samen aus der unteren und oberen flözführenden Schichtenfolge gleich breit waren, waren die von uns vermessenen Funde von allen Fundstellen breiter. Bei der Vermessung des Breiten-Indexes spielt jedoch der subjektive Faktor eine bestimmte Rolle, da von den unterschiedlich zusammengedrückten Exemplaren eine Auswahl für Vermessungszwecke getroffen werden muß.



2. Die Breiten-Werte der vermessenen *Stratiotes*-Samen aus dem mitteleuropäischen Neogen *1–6* – vgl. Abb. 1

*Längen- und Breiten-Index*

Bei der Betrachtung der vermessenen Längen- und Breiten-Werte fällt bei allen vermessenen Werten eine große Unausgeglichenheit der Resultate auf. Das Ergebnis ist eine unausgeglichene Gaußsche Kurve. In den Abb. 1 und 2 kommt diese Unausgeglichenheit nicht so gut zum Ausdruck, als wenn man die Werte, wie man sie beim Ablesen des Okularmikrometers erhält, miteinander vergleicht. Bei den Samen aus der Bohrung Bernartice treffen wir bei dem Längen-Index folgende Werte an (Teile der Skala des Okularmikrometers: Anzahl der Samen, Okular 25 ×, Objektiv 6,3 ×): 80 : 1, 81 : 4, 82 : 3, 83 : 2, 84 : 2, 85 : 9, 86 : 2, 87 : 4, 88 : 4, 89 : 4, 90 : 11, 92 : 4, 93 : 1, 95 : 4, 96 : 1, 97 : 0, 98 : 3, 99 : 3, 100 : 2, 101 : 0, 102 : 2, 103 : 0, 104 : 2, 105 : 0, 106 : 1, 107—109 : 0, 110 : 1 Samen. Auch durch subjektive Einflüsse beim Messen können die zahlreichen großen Differenzen der Meßwerte nicht erklärt werden.

Ähnliche Unausgeglichenheiten der Meßwerte machen sie auch bei den von Holý und Bůžek (1966) veröffentlichten Kurven bemerkbar, obwohl den Autoren sehr viel Material zur Verfügung stand. So erreichen die Samen aus dem unteren Teil der flözführenden Schichtenfolge bei dem Längen-Wert 5,4 mm rund 13 %, bei 6,0 mm rund 15 %, bei Funden aus dem oberen Teil der flözführenden Schichtenfolge bei dem Längen-Wert von 6,0 mm rund 11 %, beim Längenwert 6,9 mm rund 14,5 %.

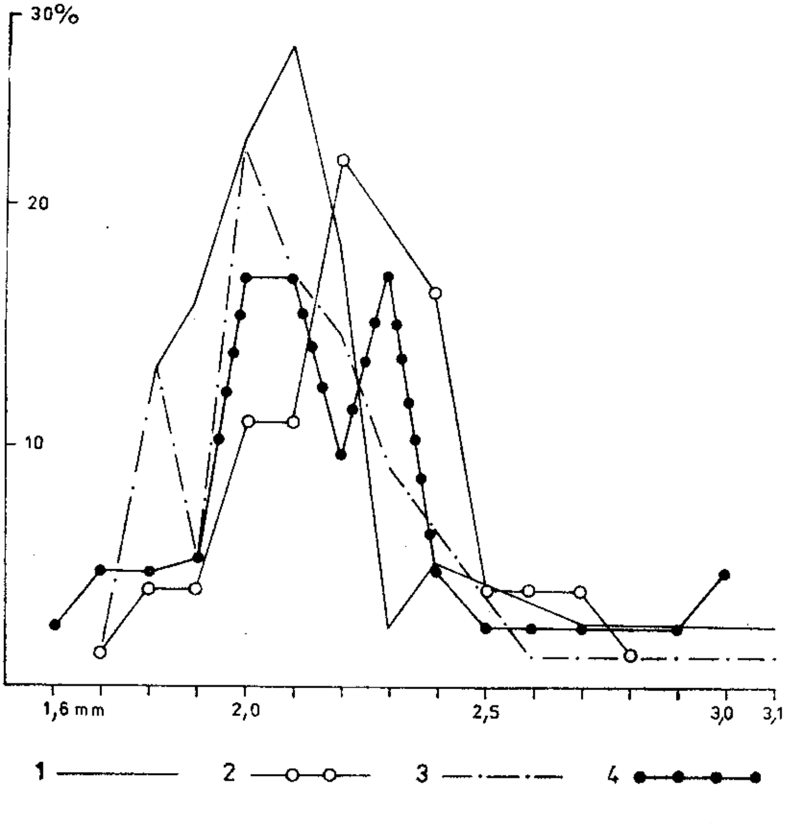
Die Prozentsätze zwischen den Längen-Werten 5,4—6,0 mm und 6,0—6,9 mm sind beträchtlich geringer und liegen meistens bei oder unter 10 %.

Da die Meßwerte sowie die danach konstruierten Kurven sehr unausgeglichen sind, ist es auch schwierig, die Meßwerte von Samen von verschiedenen Fundstellen und verschiedenaltrigen Schichten miteinander zu vergleichen. Dies wäre nur dann möglich, wenn z. B. beim Längen-Index die Zahl der Exemplare dem Mittelwert zu allmählich zu- und abnehmen würden. Dies war bei unseren sowie bei den Messungen von Bůžek und Holý nicht der Fall.

Die vom Verfasser vermessenen Samen von 4 Fundstellen oder Fundstellengruppen (im Pannon und Pont handelt es sich um Funde von zahlreichen Bohrungen, die an zwei stratigraphische Einheiten gebunden sind: an das Kyjov- und Dubňany-Flöz) gehören zu Populationen, die möglicherweise keiner biologisch und taxonomisch einheitlichen Art entsprechen. Der Verfasser vertritt die Ansicht, daß auf den jeweiligen Fundstellen vielleicht zwei verschiedene *Stratiotes*-Arten vorkommen, die sich nach der Morphologie ihrer Samen nicht immer eindeutig trennen lassen. Weiter ist es möglich, daß die Unterscheidung von zwei oder mehreren fossilen Arten, die sich morphologisch nicht eindeutig trennen lassen, durch mathematische Daten (Messungen) ebenfalls nicht immer gegeben ist. Zu diesem Verdacht führen den Verfasser frühere Untersuchungen von anderen Taxa, die ebenfalls nicht zu dem erwünschten Ergebnis führten: *Sparganium neglectum* Beeby foss. (vgl. Knobloch - Mai 1975), *Microcarpolithes guttaeformis*

KNOBL. und *Coprolithes hexagonalis* (VANG.) KNOBL. (vgl. KNOBLOCH 1977) sowie *Costatheca diskoensis* (MINER) HALL (vgl. KNOBLOCH 1981c).

Die an eigenem Material vom Verfasser errechneten Mittelwerte der Größe bei den besprochenen *Stratiotes*-Samen weisen nur sehr geringe Differenzen auf. Bei der Länge schwanken sie zwischen 6,15—6,34 mm, bei der Breite von 2,76 bis 2,97 mm, das Verhältnis der Länge zur Breite beträgt 2,10—2,26. Da in dieser Hinsicht besonders der Längen-Wert wichtig ist, muß unterstrichen werden, daß insbesondere bei den eindeutig älteren (untermiozänen) Funden von Kaltennordheim (durchschnittliche Länge 6,23 mm) hinsichtlich der Funde aus den beträchtlich jüngeren Schichten des Pannons (durchschnittliche Länge 6,15 mm) keine nennenswerten Unterschiede verzeichnet werden konnten. Diese Angaben entsprechen ungefähr den unabhängig von den Untersuchungen des Verfassers notierten durchschnittlichen Größe-Angaben bei PALAMAREV (1979, Abb. 3).



3. Die Längen/Breiten-Indexe der vermessenen *Stratiotes*-Samen aus dem mitteleuropäischen Neogen
*1* — Kaltennordheim; *2* — Salzhausen; *3* — Bernartice; *4* — Pannon und Pont im Wiener Becken

### Längen/Breiten-Index (Abb. 3)

Die prozentuale Auswertung des Längen/Breiten-Indexes weist meistens nicht genügend ausgeglichene Kurven auf. Aus dieser Auswertung geht indirekt ziemlich eindeutig hervor, daß die breitesten Samen aus dem Sarmat von Bernartice bekannt sind. Es folgen die Funde aus dem Untermiozän von Kaltennordheim, dem Mittelmiozän von Salzhausen und dem Pannon und Pont des Wiener Beckens und der Donauebene, wo neben breiten (oder nur breitgedrückten?) wirklich zahlreiche schmale und in die Länge gezogene Samen vorkommen.

### Lage des Hilums und der Raphe

Bei den Samen aus dem nordböhmischen Untermiozän überwiegen Formen, bei denen das Hilum basal orientiert ist (61 % im unteren, 88 % im oberen Teil der flözführenden Schichtenfolge). Bei den Funden aus Salzhausen überwiegen ebenfalls Klappen mit einem basal orientierten Hilum (21 Ex., 61,8 %), wogegen bei den Funden aus Bernartice (23 Ex.), aus dem Pannon (7 Ex.) und Pont (6 Ex.) nur ein basal orientiertes Hilum beobachtet wurde.

Die Raphe ist bei den Samen aus dem nordböhmischen Tertiär vorwiegend marginal: 58 % der Funde aus dem unteren Teil und 90 % der Funde aus dem oberen Teil der flözführenden Schichtenfolge. In Salzhausen kommen überwiegend Formen mit einer diagonalen Raphe vor (28 Ex., 72,4 %) wogegen nur bei 6 Samen (17,6 %) eine marginale Raphe vorkommt. In Bernartice kommt es zu einem Gleichgewicht (11 : 12 Ex. – diagonal : marginal), wogegen von 7 Samen aus dem Pannon (Bohrung Těmice UH-15) 2 Samen eine diagonale und 5 eine marginale Raphe aufwiesen und die Samen aus dem Bereich des Dubňany-Flözes (Pont) nur eine marginale Raphe besaßen (6 Ex.). Aus Kaltennordheim lagen keine dehiszierten Samen vor.

### Lage der Mikropyle

Was die Benutzung der Termini „ventral" und „dorsal" anbelangt, so geschah dies in diesem Aufsatz im Einklang mit der graphischen Darstellung bei Holý und Bůžek (1966, Abb. 11). Zur Zeit vertritt Herr Dr. Bůžek (mündliche Mitteilung vom 28. 10. 1986) im Einklang mit anderen Forschern (z. B. Kirchheimer) und entgegen Dorofeev die Ansicht, daß als Ventralseite die Seite mit der Raphe und dem Kiel bezeichnet werden muß, also umgedreht als früher erwähnt wurde und hier gehandhabt wird.

Nach Reid (1920) soll sich *Stratiotes kaltennordheimensis* von *S. tuberculatus* durch die Lage der Mikropyle unterscheiden. Wie aus den Abbildungen und Vermessungen von *S. kaltennordheimensis* bei HOLÝ - BŮŽEK (1966) hervorgeht, ist die Mikropyle bei dieser Art nicht basal, wie von Reid erwähnt wurde, sondern subbasal — der Winkel der Mikropyle hinsichtlich der gedachten Symmetrieachse beträgt 20—75°, meistens 30—55°. Obwohl bei den wenig zahlreichen Funden aus dem Pannon und Pont keine Messungen durchgeführt wurden, läßt sich sagen, daß bei 7 Samen eine subbasale Mikropyle vorkommt, wogegen bei 4 Samen die Mikropyle ventral orientiert ist (unter rund 90° gegenüber der Symmetrieachse). Bei zwei Klappen wurde eine Mittelstellung beobachtet, wobei der Winkel gegenüber der Symmetrieachse jedoch immerhin schätzungsweise 60—70° betrug. Da bei keinem Exemplar aus dem nordböhmischen Untermiozän ein Winkel von 90° beobachtet werden konnte, dürfen wir hier wohl von einem primären Entwicklungsmerkmal sprechen, das durch eine stärkere Krümmung des Mikropylenkragens bei diesen Funden hervorgerufen wurde.

Bei den Samen aus Salzhausen und Bernartice ist der Mikropylenkanal sehr schlecht oder überhaupt nicht sichtbar. Während bei den Klappen aus Salzhausen die Mikropyle subbasal orientiert ist, läßt sich die Frage bei den Samen aus Bernartice oft nicht objektiv entscheiden. Man kann jedoch auch hier annehmen, daß die Mikropyle subbasal orientiert war.

### *Variabilität der Oberflächenskulpturen, des Kiels und des Mikropylenkragens*

Die Funde aus Kaltennordheim, Salzhausen und Bernartice weisen hinsichtlich der in der Überschrift erwähnten Merkmale eine weitgehende Übereinstimmung auf. Die Dorsalseite ist stark gekrümmt — insbesondere im basalen Teil, wogegen die Ventralseite schwach gekrümmt ist oder auch gerade sein kann. Manchmal ist auch die Dorsalseite nur ganz schwach gekrümmt, so daß beide Seiten relativ parallelläufig sind. Die Samen sind dann ausgesprochen länglich. Der Mikropylenkragen kann ausgesprochen kugelförmig sein (vgl. Taf. IV, Fig. 7), rund, eingeschnürt, kann aber auch beträchtlich reduziert sein, so daß er klein ist und morphologisch wenig zur Geltung kommt (Taf. I, Fig. 4). Die Oberfläche wird von Höckern gebildet, die in Längsreihen angeordnet sind und mehr oder weniger miteinander verschmolzen sein können. Bei den Funden aus Bernartice läßt sich auf der gesamten Oberfläche eine deutliche feinwabige Struktur feststellen (auf den Höckern sowie zwischen ihnen), die auf die Sklereiden der Sklerotesta zurückzuführen ist. Diese Struktur kommt bei den Funden aus Kaltennordheim und Salzhausen weniger stark zur Geltung, was allerdings auf sekundäre Faktoren zurückzuführen ist (Erhaltungszustand bei Salzhausen, starke Inkohlung bei Kaltennordheim). Der Kiel ist in allen Fällen ausgesprochen stark, massiv und verläuft praktisch entlang der ganzen Dorsalseite. Erst kurz vor dem Apex verbreitert er sich ein klein wenig keilförmig.

Gegenüber den erwähnten Funden weisen die Samen aus dem Pannon und Pont eine teilweise unterschiedliche Oberflächenskulptur auf. Die von Höckern gebildeten Längsreihen sind oft in einzelne, relativ große Höcker aufgelöst, wobei sich natürlich eine Längsanordnung erkennen läßt. Die feine, von den Sklereiden herrührende Wabenstruktur, ist bei Funden von nur einigen Fundstellen sehr gut erhalten (z. B. Aradpuszta – Cf 300 Svodín, 243,0–246,0 m).

Während der Kiel bei den Funden aus Kaltennordheim und Salzhausen sehr kräftig (massiv) ist und sich in gleicher Breite entlang der ganzen Dorsalseite hinzieht, bemerken wir bei manchen Exemplaren aus Bernartice (außer dem gleichen Charakter), daß er sich schon ab der Mitte oder im terminalen Drittel keilförmig verbreitert. Dieses Merkmal entwickelt sich weiter bei den Funden aus dem Pannon, bei denen der Kiel erstens nicht so massiv entwickelt sein muß und zweitens eine größere keilförmige Verbreiterung als bei den Samen aus den älteren Schichten aufweisen kann (vgl. Taf. III, Fig. 4, Taf. IV, Fig. 10). Bei den Funden aus Pont-de-Gail wurde dieses Merkmal nicht abgebildet. Reid spricht lediglich von kleineren und feineren Höckerchen bei *Stratiotes tuberculatus*, wie auch aus den Abbildungen hervorzugehen scheint (vgl. REID 1920, Taf. III, Fig. 6, 7). Der Mikropylenkragen ist bei den Funden aus dem Pannon und Pont im Durchschnitt viel kleiner und manchmal sehr dicht mit Höckerchen besetzt (vgl. Taf. IV, Fig. 1, 2, 4), was bei den stratigraphisch älteren Funden nicht zutrifft, da dort der Mikropylenkragen „glatt“ (vgl. auch HOLÝ - BŮŽEK, 1966, Taf. III, Fig. 3, 4) oder auf jeden Fall viel schwächer ornamentiert ist.

Aber auch bei der Oberflächenskulptur gibt es zahlreiche Ausnahmen. In der Bohrung Dubňany PVP-13 kommen in der gleichen Probe Samen vor, bei denen die Höckerchen in mehr oder minder unterbrochenen Längsreihen angeordnet sind, bei einem anderen Samen ist dies nicht der Fall. Gemeinsam für diese Funde ist der sehr kleine Mikropylenkragen.

## **Abgrenzung von** *Stratiotes kaltennordheimensis* (ZENK.) KEILH. **zu** *Stratiotes tuberculatus* REID

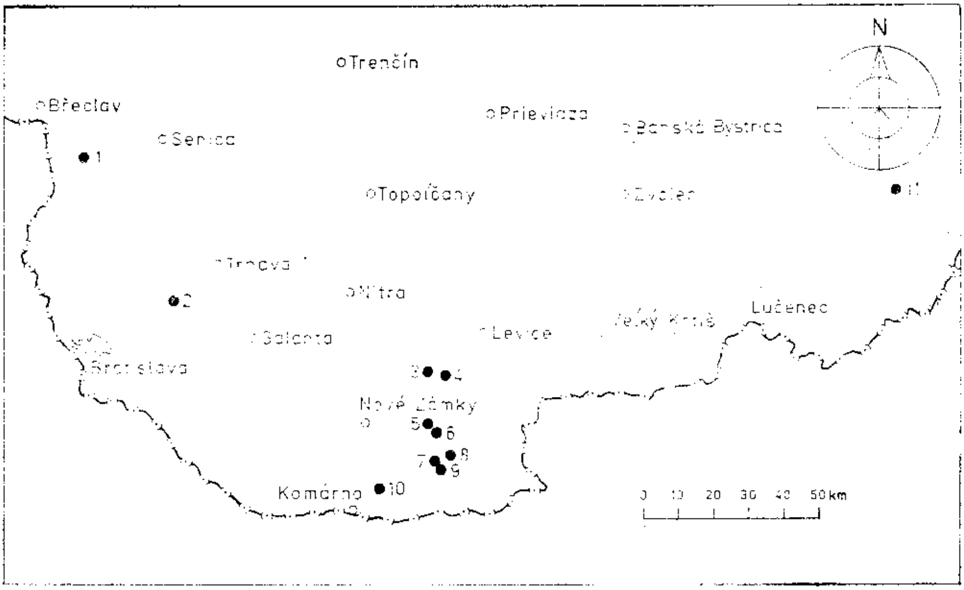
Bei der Auswertung der verschiedensten morphologischen Merkmale war das Augenmerk des Verfassers besonders auf die Funde aus dem Pannon und Pont des Wiener Beckens in Beziehung zu den Samen aus älteren miozänen Schichten gerichtet. Gerade im Pannon ließ sich die Anwesenheit einer anderen Art als *Stratiotes kaltennordheimensis* vermuten.

Die hier erstmals vorgelegte reichere Dokumentation zu diesem Problemkreis beweist wohl zur Genüge, wie sich die verschiedenen Merkmale gegenseitig überschneiden und wie sie durchkombiniert sind, so daß man manchmal auch anhand der Samen aus einer Probe von zwei, gegebenenfalls auch mehreren Arten sprechen könnte.

Die typischen Funde, die in dieser Arbeit als *Stratiotes tuberculatus* Reid bezeichnet werden, lassen sich durch folgende Merkmale charakterisieren: Form länglich, Dorsal- und Ventralseite gegenseitig relativ parallel verlaufend, Oberfläche mit Höckern verziert, die in Reihen angeordnet sein können, oftmals bilden sie jedoch keine ausgesprochenen Reihen (Taf. III, Fig. 5–7, Taf. IV, Fig. 6), sondern weisen nur eine Längsorientierung auf. Der Mikropylenkragen ist selten kugelförmig, meistens ist er klein oder sehr klein, oft stark reduziert, verschmälert, stark zur Seite gedreht (basiventral), das Hilum basal, die Raphe marginal.

### Verbreitung der Gattung *Stratiotes* L. im tschechoslowakischen Neogen

Die bis 1966 veröffentlichten Funde aus dem böhmischen Neogen wurden in der Arbeit von Holý - Bůžek (1966) zusammengefaßt, so daß auf diese verwiesen werden kann. Im folgenden wird eine Übersicht der bisher aus dem mährischen sowie slowakischen Neogen bekannten Funde gegeben.



4. Die Verbreitung der Gattung *Stratiotes* L. im Neogen der Slowakei
*1* — Čáry (Gbely GB-3-H); *2* — Blatné (Cf B1-5); *3* — Bardoňovo (Cf 300 Pozba-66), Pozba (Cf 600 Šurany-6); *4* – Čaka (Cf 300 Svodín-133); *5* — Jásová (Cf 300 Svodín-112, 164); *6* — Dubník (Cf 600 Komárno-28); *7* — Strekov (Cf 600 Komárno-23, 25); *8* — Svodín (Cf 300 Svodín-77, 78); *9* — Aradpuszta (Cf 300 Svodín-27, 40); *10* — Chotín (Cf 600 Komárno-5); *11* — Rákoš (Cf 600 Slanec-I)

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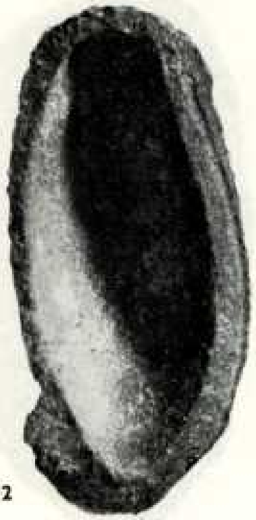
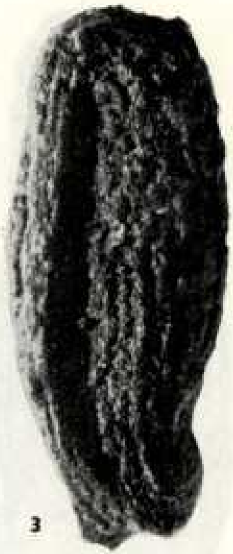
von *Stratiotes kaltennordheimensis* und *S. tuberculatus*

Taf. I

1



2



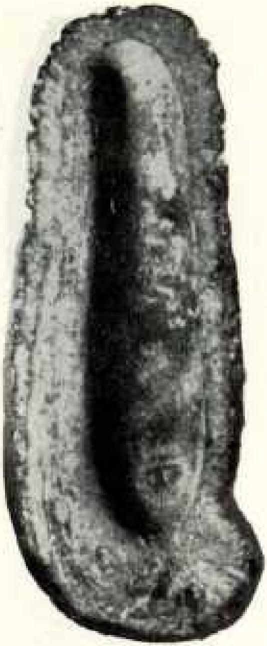
3

4

5

6

Taf. II


1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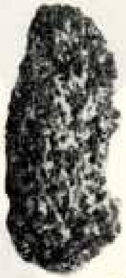
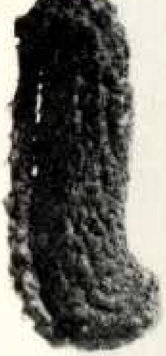
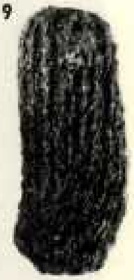

6


7


8


9


10


11


12


13

Veröffentlichte Funde:

Untermiozän bis tiefes Mittelmiozän:
Šafov (Knobloch 1978);

Ober-Baden bis Sarmat:
Bernartice (Knobloch 1969, 1982);

Pannon (Zone B—C):
Čejč (Unger 1850, 1861, Holý - Bůžek 1966, Knobloch 1969),
Kunovice (Knobloch 1976),
Kyjov (Hofmann 1900),
Ořechov, Těmice (Čtyroký - Knobloch 1976);

Pont (Pannon, Zone F):
Poštorná (Bůžek 1962),
Čáry, Jásová (Knobloch 1981b),
Dolní Bojanovice, Dubňany, Lužice, Prušánky, Velké Bílovice (Knobloch 1981a).

Unveröffentlichte Funde:

Meistens handelt es sich um Bruchstücke, die nur den Nachweis der Gattung von zahlreichen Stellen des slowakischen Neogens bilden und so Hinweise für zukünftige Forschungen darstellen. Die vollständig erhaltenen Samen (vgl. z. B. Taf. IV, Fig. 3) stellen Übergangsformen von *Stratiotes kaltennordheimensis* zu *S. tuberculatus* dar. Diese Funde sind im folgenden nach den jeweiligen Gemeinde-Katastern bezeichnet (die zweite Bezeichnung bezieht sich auf die Bohraktion, unter der die Bohrungen in den Bohrarchiven der Erdölfirmen angeführt werden, z. B. Cf 300 Svodín ist das Bohrprojekt Svodín, das auf dem Gebiet von vielen Gemeinden realisiert wurde; Cf = Counterflush = Bohren mit Umkehrspülung).

Untersarmat:
Rákoš (Cf 600 Slanec-I, 151,0—155,0 m, 1 Fragm.);

Pannon oder unteres Pont:
Aradpuszta (Cf 300 Svodín-37, 243,0—246,0 m, 5 Fragm., Cf 300 Svodín-40, 230,0—235,0 m, 1 Fragm., Cf 300 Svodín-41, 143,0—148,0 m, 1 Fragm.),
Bardoňovo (Cf 300 Pozba-66, 291,0—295,0 m, 2 Fragm.),
Blatné (Cf 300 Bl-5, 132,0—142,0 m, 2 Fragm.),
Čaka (Cf 300 Svodín-133, 55,0—60,0 m, 6 Fragm.),
Dubník (Cf 600 Komárno-28, 540,0—545,0 m, 2 Fragm.),
Chotín (Cf 600 Komárno-5, 540,0—545,0 m, 2 Fragm.),
Jásová (Cf 300 Svodín-164, 270,0—280,0 m, 2 Fragm.),
Pozba (Cf 600 Šurany-6, 301,0—305,0 m, 1 Fragm.),
Strekov (Cf 600 Komárno-23, 478,0—482,0 m, 1 Fragm., 483,0—485,0 m, 1 Fragm., 533,0—537,0 m, 4 Fragm., Cf 600 Komárno-25, 480,0—484,0 m, 1 Ex.),

Svodín (Cf 300 Svodín-77, 115,0–120,0 m, 2 Fragm., Cf 300 Svodín-78, 240,0 bis 245,0 m, 1 Fragm.).

*K tisku doporučil Č. Bůžek*
*Přeložil autor*

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## Erläuterungen zu den Tafeln

### Taf. I

1–6. *Stratiotes kaltennordheimensis* (ZENK.) KEILH., 10×. 1 – Salzhausen; 2 – Salzhausen, diagonal-marginale Raphe; 3 – Kaltennordheim; 4 – Salzhausen; 5 – Kaltennordheim, besonders breiter Kiel; 6 – Salzhausen, Mikropylenkragen nicht eingekrümmt.

Fotos ÚÚG – V. Skala

### Taf. II

1–6. *Stratiotes kaltennordheimensis* (ZENK.) KEILH., 12×. 1–5 – Bernartice U-58, 216,7–221,5 m; 6 – Bernartice U-49, 80,0–84,0 m.

Fotos ÚÚG – H. Vršťalová

### Taf. III

1–7. *Stratiotes tuberculatus* E. M. REID. 1 – Těmice UH-15, 28,9 m, Pannon, Zone C, Raphe diagonal, Mikropylenkanal basiventral, Hilum basal, 8,5×; 2 – Ořechov UH-22, 23,5 m, Pannon, Zone B–C, Mikropylenkragen teilweise abgebrochen, Höcker in deutlichen Reihen angeordnet, Oberfläche mit dichten, kleinen, polygonalen Feldern bedeckt, 10×; 3 – Dubňany PVP-13, ohne Tiefenangabe, Pont, sehr kleiner Mikropylenkragen, subbasal orientierte Mikropyle, 7×; 4 – Dolní Bojanovice Hb-6, ohne Tiefenangabe, Pont, apikal sehr stark verbreiterter Kiel, unten rechts ein Stück des Samens abgebrochen, 9×; 5 – Lužice PVP-31A, 195,0–195,4 m, Pont, grobe Oberflächenskulptur in undeutlichen Reihen angeordnet, Mikropylenkragen stark reduziert, 9×; 6 – Dubňany PVP-13, ohne Tiefenangabe, Pont, grobe Oberflächenskulptur, kleiner, morphologisch undeutlich abgegrenzter Mikropylenkragen, skulpturiert, 12×; 7 – Oberfläche mit Höckern, die nicht in Reihen angeordnet sind, Mikropylenkragen sehr klein, 10×.

Fotos ÚÚG – V. Skala

### Taf. IV

1, 3, 5, 13. *Stratiotes* cf. *tuberculatus* E. M. REID vel *Stratiotes* cf. *kaltennordheimensis* (ZENK.) KEILH. 1 – Těmice UH-15, 28,9 m, Pannon, Zone B, Höcker in zahlreichen Reihen angeordnet, 8×; 3 – Strekov (Cf 600 Komárno-25), 480, 0–484,0 m, Pannon oder Pont, 7×; 5 – Dolní Bojanovice Hb-6, 155,9 m, Pont, links oben mit *Azolla* sp., Höcker groß, schuppenförmig, teilweise abgerieben, zum Unterschied von Fig. 4 (Salzhausen) nicht in Reihen angeordnet, Mikropylenkragen stark zur Seite gedreht (basiventral), auf den Höckern 4–5eckige abgerundete Vertiefungen, 10×; 13 – Těmice UH-15, 28,9 m, Pannon, Zone B, 8×.

2, 6, 8–12. *Stratiotes tuberculatus* E. M. REID. 2, 8 – Těmice UH-15, 28,9 m, Pannon, Zone B, Form länglich, 8×; 6 – Dubňany PVP-11, 53,0–54,0 m, 6×; 9–12 – Dolní Bojanovice, Hb-6, 17,8 m, Pont, 9×.

4, 7. *Stratiotes kaltennordheimensis* (ZENK.) KEILH. 4 – Salzhausen (zum Vergleich mit Fig. 5), 10×; 7 – Bernartice U-58, 216,7–221,5 m (zum Vergleich mit den schmäleren Samen aus dem Pannon und Pont), abgerundeter Mikropylenknopf, Oberflächenskulptur: in Reihen angeordnete Höcker, 12×.

Fotos ÚÚG – 1, 2, 4, 5, 8, 10–13 V. Skala; 3 B. Matoulková; 6 A. Kadlecová; 7, 9 H. Vršťalová

# Biometrie a morfologie semen druhů Stratiotes kaltennordheimensis a S. tuberculatus ze středoevropského neogénu

(*Résumé německého textu*)

ERVÍN KNOBLOCH

Předloženo 6. října 1986

HOLÝ a BŮŽEK (1966) se zabývali podrobně variačně statistickými výzkumy druhu *Stratiotes kaltennordheimensis* (ZENK.) KEILH. ze slojového souvrství severočeské hnědouhelné pánve (spodní miocén). Při tom zjistili, že semena ze spodní části slojového souvrství jsou vzhledem k jeho svrchní části v průměru delší a mají odlišné procentuální zastoupení v různých typech postavení hila, v odlišném průběhu rafe a ve velikosti úhlu, který svírá mikropylární kanálek vzhledem k pomyslné čáře proložené osou symetrie semene. Další nedořešenou otázkou bylo, zda druh *Stratiotes tuberculatus* REID (1920) je dobrým samostatným druhem, jak to předpokládají BŮŽEK a HOLÝ (1966) a PALAMAREV (1978), nebo zda je nutno ho sloučit se *Stratiotes kaltennordheimensis* (ZENK.) KEILH., jak to navrhuje KIRCHHEIMER (1957). Cílem tohoto článku je ukázat, do jaké míry se mění jednotlivé znaky u stratigraficky mladších nálezů *Stratiotes kaltennordheimensis* ve vztahu ke stratigraficky starším nálezům tohoto druhu, a to se zvláštním zřetelem na možnost existence jiného druhu rodu *Stratiotes* v panonských uloženinách. Pro tyto výzkumy měl autor článku k dispozici nálezy z lokalit Kaltennordheim (locus typicus studovaného druhu, spodní miocén), Salzhausen (střední miocén), Bernartice (svrchní baden až sarmat) a z vrtů hloubených v panonu (zóny B) a pontu (= panon, zóna F) z vídeňské a podunajské pánve.

Délka kolísá u stratigraficky odlišně starých nálezů jen málo (viz obr. 1, 2). Je zajímavé, že kumulativní křivky od našich nálezů různého stáří leží mezi kumulativními křivkami, které byly získány proměřováním semen ze spodní a svrchní části slojového souvrství v severočeské pánvi (tj. ze sedimentů, které reprezentují v rámci miocénu poměrně krátký časový úsek). Semena z Kaltennordheimu a mladších sedimentů jsou širší než ze severočeského spodního miocénu, pokud toto zjištění není způsobeno subjektivním výběrem různě silně deformovaných semen, které byly proměřovány. Interpretace indexu délky a šířky ukázala nepřímo, že nejširší semena se vyskytují v Bernarticích, nejužší v panonu. Matematický průměr indexu šířky a délky vykazuje malé rozpětí (mezi 2,1 u nálezů z Kaltennordheimu a 2,6 u nálezů ze Salzhausenu). Zatímco v Salzhausenu jsou semena s bazálním hilem zastoupena 61,8 %, u mladších nálezů se vyskytuje jen bazální hilum. Zatímco v západočeském miocénu převládají semena s marginálním rafe, v Bernarticích byla nalezena semena s marginálním a diagonálním rafe v přibližně stejném počtu, v panonu a pontu převládají semena s marginálním rafe. Mikropylární kanálek je u stratigraficky starších nálezů orientován vzhledem k pomyslné čáře vedené středem symetrie semene subbazálně, u nálezů z panonu a pontu se vyskytují také semena s ventrální orientací mikropylárního kanálku (úhel až 90°). Četné nálezy z panonu a pontu nemají povrchovou skulptaci uspořádanou do podélných řad, nýbrž mají povrch zdobený víceméně nepravidelně rozmístěnými hrbolky.

*Stratiotes tuberculatus* představuje další vývojové stadium druhu *S. kaltennordheimensis*, s kterým je tento druh spojen s některými přechodnými formami. V typických formách je *S. tuberculatus* charakterizován velice podlouhlým tvarem (dorzální a ventrální strana probíhají vzájemně rovnoběžně), mikropylární límec je malý až redukovaný, velmi silně stočený ke straně a povrchová skulptace vykazuje sice podélné uspořádání, ale hrbolky nebývají v tak pravidelných řadách.

## **Биометрия и морфология семян видов** *Stratiotes kaltennordheimensis* **и** *S. tuberculatuus* **из неогена средней Европы**

Представленная статья исходит из исследований авторов Голы и Бужек (HOLÝ — BŮŽEK 1966), которые детально занимались изменяемостью и статистическим изучением вида *Stratiotes kaltennordheimensis* в нижнем миоцене Северочешского бассейна. Автор представленной статьи сравнивает их результаты со своими заключениями, выведенными из изучения семян рода *Stratiotes* L. с нижнемиоценового местонахождения Кальтеннордхайм, с находками из среднего миоцена местонахождения Зальцхаузен, из верхнего миоцена местонахождения Бернартице и с находками из паннона и понта Венского бассейна. Обсуждается отношение вида *Stratiotes kaltennordheimensis* к виду *S. tuberculatus* и приводятся доводы за самостоятельность вида *S. tuberculatus*.

*Přeložil A. Kříž*

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