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The Wenlock/Ludlow Boundary in the Prague Basin (Bohemia)

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With 18 Text-Figures, 1 Table and 3 Plates

Tschechische Republik
Österreich
Prager Becken
Karnische Alpen
Barrandium
Silur
Stratigraphie
Korrelation
Wenlock/Ludlow-Grenze
Benthos
Graptolithen
Conodonten
Chitinozoen
Sporomorpha

Contents

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Die Wenlock/Ludlow-Grenze im Prager Becken (Böhmen)

Zusammenfassung

In dieser Arbeit werden die Ergebnisse einer interdisziplinären Zusammenarbeit über die Wenlock/Ludlow-Grenze im Silur des Barrandiums der Tschechischen Republik mitgeteilt. Der Report enthält lithologische und faunistische Neuergebnisse von 22 neu untersuchten Profilen in der Umgebung Prags (Prager Mulde), die geeignet sind, die entsprechenden Grenzschichten exakt mit der international festgelegten Grenze zwischen den Wenlock- und Ludlow-Serien im Stratotyp des Welsh Borderland (Steinbruch Pitch Coppice, Ludlow District) zu parallelisieren.

Die tieferen Teile des Prager Beckens werden durch eine kontinuierliche Graptolithenschiefer-Entwicklung gekennzeichnet. Darin manifestiert sich innerhalb der *Cyrtograptus lundgreni* Biozone (*T. testis* Subzone) die gleiche Krise in der Evolution der Graptolithen, wie von H. JAEGER (1991) aus Thüringen, Südspanien, Gotland und Litauen beschrieben. In der Flachwasserfazies des westlichen, zentralen und nördlichen Segments des Prager Beckens (J. KŘÍŽ, 1991) war hingegen die Sedimentation an der Wenlock/Ludlow-Grenze von vulkanischer Aktivität beeinflußt. Hierbei wurden lokal im jüngeren Wenlock Crinoidenkalke gebildet. Cephalopodenkalke dominieren aber und reichen von der *T. testis* Subzone in die *C. colonus* Biozone des älteren Ludlows.

Für biostratigraphische Zwecke wurde die vertikale Verbreitung von Graptolithen, Conodonten, Chitinozoen und Sporomorpha untersucht und dokumentiert und der Leitwert von Vertretern der verschiedenen Gruppen erörtert. Danach eignen sich neben Graptolithen vor allem Conodonten für die Grenzziehung zwischen Wenlock und Ludlow. Zwei neue Arten von Chitinozoen werden beschrieben. Die „Graptolithen-Krise" des jüngeren Wenlock und damit zusammenhängende Fragen und Schlußfolgerungen werden kurz diskutiert.

Abstract

The Wenlock/Ludlow boundary beds in the Prague Basin (Barrandian area, Czech Republic) were studied in great detail to provide all information necessary for international correlations within the IGCP project 216 – Bioevents, subproject Wenlock/Ludlow boundary event. In deeper parts of the Prague Basin a continuous sequence in shale facies development was discovered in which the same graptolite crisis was observed at the end of the *Cyrtograptus lundgreni* Biozone (*T. testis* Subzone) described by JAEGER (1991) from Thuringia, South Spain, Gotland and Latvia. In shallow parts of the Western Segment, Central Segment and Northern Segment of the Prague Basin (KŘÍŽ, 1991) the sedimentation was influenced by volcanic activity at the Wenlock/Ludlow boundary. Locally crinoidal limestones were deposited in the uppermost Wenlock. A cephalopod limestone biofacies was developed in the upper Wenlock (*T. testis* Biozone) and in the lowermost Ludlow (*C. colonus* Biozone). Changes in all segments of the Prague Basin are documented by 22 measured sections. The vertical distribution of graptolites, conodonts, chitinozoa and sporomorphs was studied and is described to discuss its influence during the "big graptolite crisis" and during the Wenlock/Ludlow boundary.

1. Introduction

The study of the Wenlock/Ludlow boundary was included into the research programme of the Czech Geological Survey in 1988 in connection with the IGCP project 216 – Bioevents, subproject Wenlock/Ludlow boundary event, to provide necessary data for international correlation.

The work was realized in terms of the international cooperation of the Czech Geological Survey with Geologische Bundesanstalt, Vienna, and Museum für Naturkunde, Berlin. Field investigations of the sections, conodont sampling, the study of bivalves and general biostratigraphy were carried out by J. KŘÍŽ (Czech Geological Survey, Prague), studies of conodonts were carried out by H.P. SCHÖNLAUB (Geologische Bundesanstalt, Wien), chitinozoa and sporomorphs sampling and studies were made by P. DUFKA (Czech Geological Survey, Prague). J. FRÝDA (Czech Geological Survey) identified gastropods and A. GALLE (Czech Academy of Sciences) identified corals. JAEGER (Museum für Naturkunde, Berlin) collected and identified all graptolites from the Všeradice Section and Butovice Section during his visits of the Prague Basin between 1961 and 1991. He died in 1992 and was not able to complete the work for a monograph.

2. History of Stratigraphical Studies

The first biostratigraphic subdivision of the Silurian based on graptolite zones was introduced in Bohemia by MARR (1880) who first recognized the zone with *Monograptus priodon* and the zone with *Monograptus colonus* and mentioned that he saw *Monograptus testis* only below the level with limestones and with *Monograptus colonus*. According to this observation PERNER & KODYM (1919) subdivided the lower Silurian into three parts, i.e. beds with *Diplograptus* which they named the Želkovice Beds, beds with *Monograptus priodon* which they named the Motol Beds and beds with *Monograptus dubius* which they named the Butovice Beds. In the Butovice Beds they recognized two zones – the zone with *Monograptus testis* and the higher zone with *Monograptus colonus*.

The upper zone with *Monograptus colonus* was renamed by BOUČEK (1937) *Monograptus nilssoni* Zone and assigned to the Ludlow. In the same paper BOUČEK mentioned that it is very difficult to distinguish the *Monograptus nilssoni* Zone from the higher *Monograptus scanicus* Zone.

In 1948 PRANTL & PŘIBYL described the Kopanina Formation and defined its lower boundary at the base of the *Monograptus scanicus–Pristiograptus nilssoni* Zone.

HORNÝ (1955) accepted BOUČEK's opinion (1937) that it is not possible to recognize the *Pristiograptus nilssoni* Zone in the field and proposed to use the *M. scanicus* Zone instead. In the volcanic facies, where graptolites are extremely rare in carbonate sediments, he recognized the limestone complex "Kozel" as lower Ludlow.

HORNÝ (in HORNÝ, PRANTL & VANĚK, 1958) contributed to the question of the Wenlock/Ludlow boundary in Bohemia by the discovery of a graptolite association with *Pristiograptus vulgaris* in the boreholes between the zones of *M. testis* and *M. scanicus* where they occur in the level of 5–10 m of shales. He recognized this association as the *P. vulgaris* Zone and distinguished at its base the level with monotonous association formed by *Gothograptus nassa* and *Pristiograptus* ex.gr. *dubius*. HORNÝ (in HORNÝ, PRANTL & VANĚK, 1958) correlated this association of graptolites with a similar association described from the Holy Cross Mountains by TOMCZYK (1956). Above the *Pristiograptus vulgaris* Zone HORNÝ rediscovered the *Pristiograptus nilssoni* Zone with a characteristic association of graptolites with a thickness of 5–15 m. In the volcanic facies he recognized the "Kozel"

limestone complex as the equivalent of the zone of *P. nilssoni* and lower portions of the *M. scanicus* zone, Ludlow.

HORNÝ retained in his monograph (1962) a similar opinion. He recognized the "Kozel" limestone complex as an equivalent of the *P. vulgaris* Zone and of the *P. nilssoni* Zone. In 1971 HORNÝ found in the shale facies the subzone *P. deubeli* (identified by H. JAEGER) above the "interregnum" with *Pristiograptus dubius–Gothograptus nassa* and below the characteristic *P. vulgaris* Zone. He correlated, in agreement with the results of new research of his colleagues A. GALLE, V. HAVLÍČEK, J. KŘÍŽ & J. VANEK, the "Kozel" limestone complex in the tuffitic facies with the upper parts of the zone of *T. testis* and with the *P. dubius–G. nassa* Interregnum (upper Wenlock).

In 1981 the definition and ratification of the internationally accepted Wenlock and Ludlow Series (MARTINSSON et al., 1981) was accomplished. The base of the Ludlow was defined at the base of the *Neodiversograptus nilssoni* s.l. Zone.

KŘÍŽ (1991) followed PŘIBYL's (1983) zonal subdivision of the Silurian in Bohemia and the base of the Ludlow according to the international subdivision at the base of the *N. nilssoni* Zone.

An important paper concerning the Wenlock/Ludlow boundary was published by JAEGER (1991). He proposed the new Wenlock/Ludlow boundary at the base of the new zone *Monograptus dubius parvus*. This level represents the contemporary crisis ("Große Krise") in the graptolite evolution when almost all graptolites of the older zone of *M. testis* were extinct except the species *Monograptus dubius parvus* and *Gothograptus nassa*. In Thuringia JAEGER recognized above this zone the Interregnum with *M. dubius frequens and G. nassa*, the *M. praedeubeli* Zone, the *M. deubeli* Zone and the *M. gerhardi/M. vulgaris* Zone.

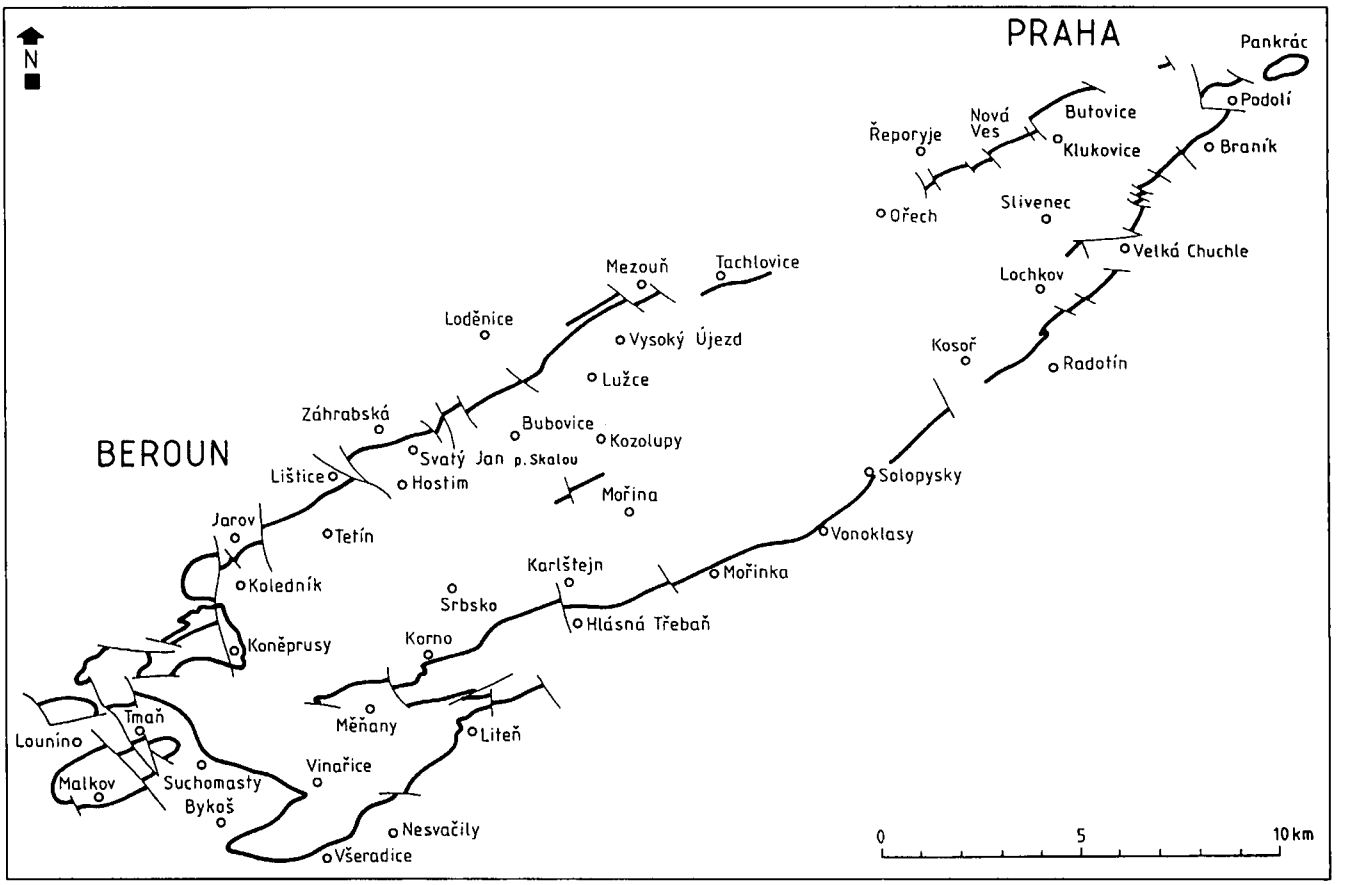
3. Facies Development of the Wenlock/Ludlow Boundary in the Prague Basin

The Wenlock/Ludlow boundary in the Prague Basin is developed in three principal facies:

1) Shale facies, with rare levels of tuffites, developed mainly in the Western Segment and the Southern Segment of the Prague Basin (KŘÍŽ, 1991).
2) Shale and cephalopod limestone facies, developed in the Nová Ves Volcanic Centre (KŘÍŽ, 1991).
3) Volcanic facies, represented by the effusive basalts and volcaniclastics, brachiopod limestones and shallow water crinoidal limestones developed mainly in the Northern Segment, in the northern part of the Central Segment, in the eastern part of the Western Segment and in the western part of the Pankrác Segment (KŘÍŽ, 1991).

4. Principal Localities of the Wenlock/Ludlow Boundary Beds in the Prague Basin

For each facies development several sections were chosen. The selected sections were measured and



Text-Fig. 1.
Distribution of the Wenlock/Ludlow boundary in the Prague Basin (Barrandian area, Central Bohemia) and principal localities.

studied bed by bed in an interval comprising mostly the whole outcrop. Beds were numbered and the faunal content collected and analyzed.

All sections of the Wenlock/Ludlow boundary are situated in the broader vicinity of Prague (Text-Fig. 1), the most distant locality is about 32 km from the city. All localities are easily accessible by public transportation system (train, bus, tram, underground) but protected by State Law. When sampling for serious scientific research is necessary, permission is given by the Protected Landscape of Bohemian Karst Area Agency, Karlštejn 85, 267 18 or by the Czech Ministry of the Environment, Kodaňská 10, Praha 10, 101 00. It is advisable to realize the research in cooperation with the Czech Geological Survey, Prague.

4.1. The Southern Segment of the Basin: Všeradice Section – No. 717

The Všeradice Section represents the shale facies development at the Wenlock/Ludlow boundary. The section is exposed along the field truck running north-north-west from the road Všeradice–Bykoš, north-west of the Všeradice Village (Text-Figs. 1, 2).

A generalized draft of the Všeradice section was published by HORNÝ (1960). The section was studied in detail by J. KŘÍŽ, P. DUFKA & H. JAEGER in summer 1991.

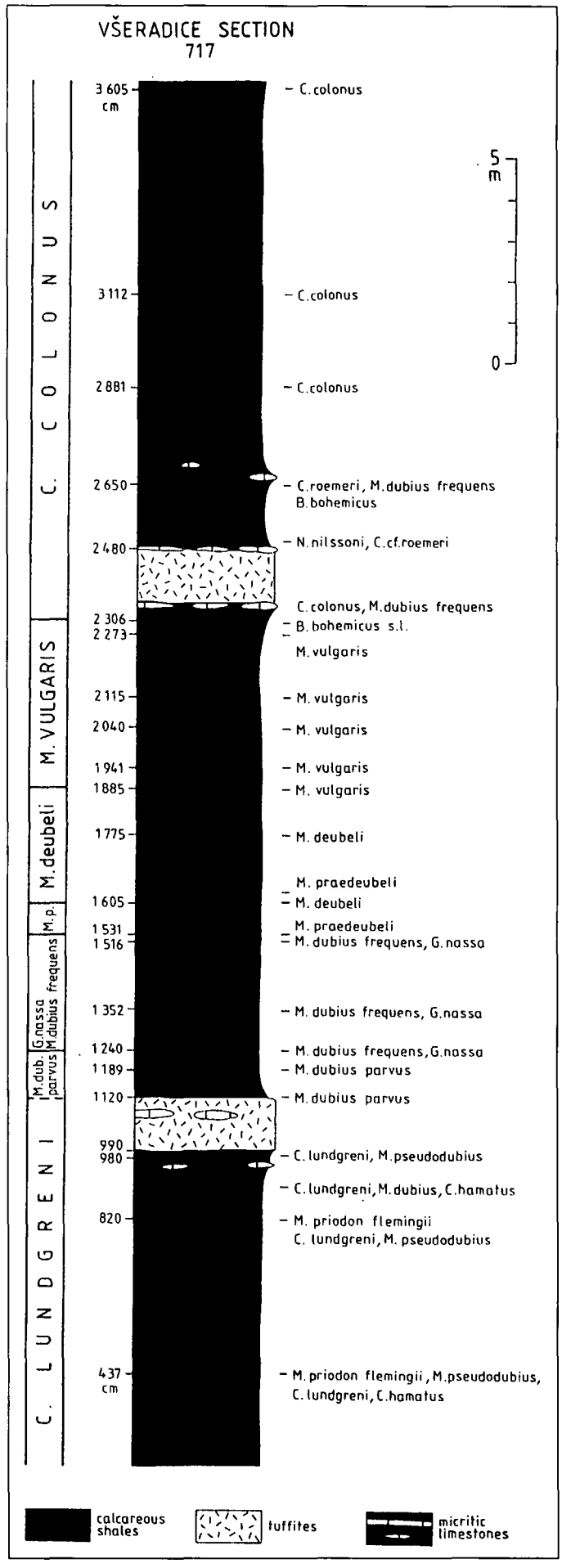
The section starts close to the road in the *M. belophorus* Biozone. The following section is not continuously exposed up to the upper portions of the *C. lundgreni* Biozone which is exposed on the left side of the truck 120 m from the milestone no. 2 on the main road. From this point the whole section is exposed up to the *C. colonus* Biozone.

The upper parts of the *C. lundgreni* Biozone are characterized by dark calcareous shales. They contain the graptolites *M. priodon flemingii*, *C. hamatus*, *M. dubius*, *M. pseudodubius*, *C. lundgreni* and retiolitids. The uppermost parts are developed as dark brown tuffaceous shales and terminated by 130 cm thick grey tuffites with thin intercalation of grey micritic limestones.

Above the tuffite, 133.8 metres from the milestone on the main road, the base of the *M. dubius parvus* Biozone, developed as brownish grey shales is exposed. The biozone is characterized by the occurrence of only two graptolites: *M. dubius parvus* and *Gothograptus nassa*. Its thickness is 120 cm. The basal 15 cm contain a rich brachiopod and trilobite fauna: *Mezounia bicuspis*, *Craniops nana*, *Bracteoleptaena bracteola*, *Strophochonetes zephyrus*, *Ravozetina quaziprokopia*, *Borkopleura gorella*, *Decoroproetus miser miser*, *Delops*? *orbus*, *Raphiophorus roualti*, *Rabuloproetus borekensis*, *Radnoria* sp., *"Ortotheca" pulchra*, *"Plumulites" minimus* and *Kolihaia eremita*.

The section continues by 290 cm thick brown calcareous shales of the *M. dubius frequens – Gothograptus nassa* Interregnum with characteristic graptolites and the cephalopod *Aptychopsis* sp.

Brownish calcareous shales correspond to the *M. praedeubeli* Biozone (90 cm thick) and to the *M. deubeli* Biozone (280 cm thick). The *M. vulgaris* Biozone follows, developed again as light brownish calcareous shales



Text-Fig. 2.
Všeradice Section (no. 717) near Všeradice with fossil ranges.

(420 cm thick). Besides the index species which is the most common, a few indeterminable cephalopods, retiolitids and *M.* cf. *dubius frequens* occur.

Higher in the sequence is the level of relatively large nodules of grey micritic limestone above a few centimetres of brownish shales which contain *Colonograptus colonus*, *M. dubius frequens*, *Bohemograptus bohemicus* s.l. and correspond to the *C. colonus* (*Neodiversograptus nilssoni*) Biozone. The level with nodules is overlain by 135 cm rusty yellow tuffites without fossils. Above the tuffite level another level of relatively large nodules of dark micritic limestone is developed. The *C. colonus* Biozone follows at least to 13 m above its base and contains a characteristic association of the graptolites *C. colonus*, *C. roemeri*, *M. dubius frequens*, *Bohemograptus bohemicus*, *Plectograptus macilentus*, *Neodiversograptus nilssoni* a.o. 50 cm above the tuffite level the only determinable palynomorphs in the micritic limestone nodule were discovered. Most common are phosphate mazulleoids, only three species of chitinozoans were found. Of them only *Linochitina erratica* described from the Wenlock/Ludlow boundary rocks in England and Baltoscandinavia is biostratigraphically important.

The section continues higher up by brownish calcareous shales of the *M. fritschi linearis* Biozone which continue with few nodules or thin limestone lenses 23.40 m up to the limestone level with the trilobite *Ananaspis fecunda* and characteristic brachiopods of the *Ananaspis fecunda-Cyrtia postera* Community (HAVLÍČEK & ŠTORCH, 1990). It is equivalent to the basal parts of the horizon with *Ananaspis fecunda* in the Kosov Quarry.

Conodont samples from below and above the tuffite at the base of the *C. colonus* Zone did not provide any stratigraphically important taxa.

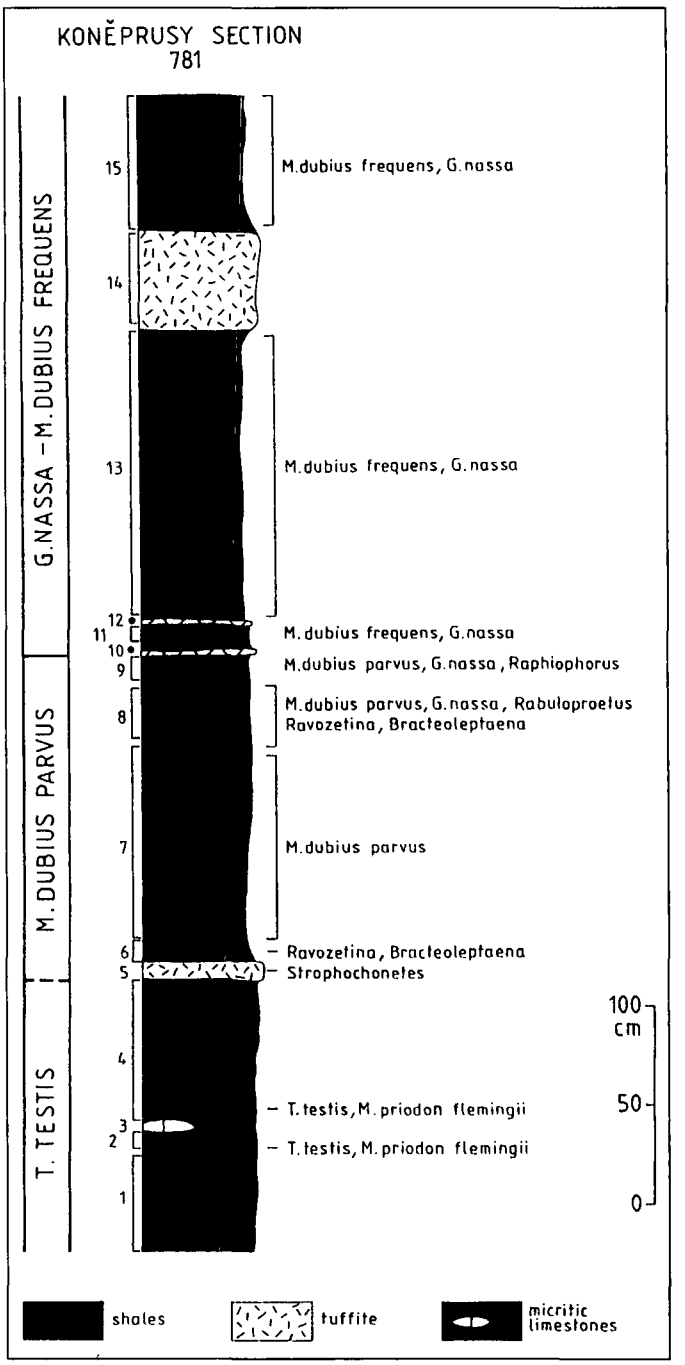
4.2. The Western Segment of the Prague Basin: Koněprusy Section – No. 781

The section lies along the road cut east of the Koněprusy Village near the road from Koledník Hamlet to Suchomasty Village on the western slope of the Malý Vrch Hill (Text-Fig. 1, 3).

The outcrop was discovered and studied in 1991 by KŘÍŽ (1992). The section is in the shale facies. It starts by 200 cm of dark graptolitic shales of the *T. testis* Subzone. Then about 60 cm of shales follow in which graptolites were not found. They are overlain by 170 cm of mostly dark, thin bedded shales with *M. dubius parvus* and *G. nassa* which have a thin layer of tuffite on the base. In the upper 44 cm a common trilobite and brachiopod fauna occurs underlying another thin bed of tuffite: *Raphiophorus roualti*, *Rabuloproetus borekensis*, *Miraspis simara babaricha*, *Odontopleura* aff. *salma*, *Strophochenetes zephyrus*, *Bracteoleptaena bracteola*, *"Lingula" unguis*, *Ravozetina quaziprokopia*, *Lissatrypa* sp., *Mezounia bicuspis*, *"Chonetes"* sp. and *"Rhynchonella"* indet., *"Plumulites" minimus*, *"Ortotheca" pulchra* and the graptolites *M. dubius parvus* and *Gothograptus nassa*.

Further up the section continues by 160 cm of dark thin-bedded shales with common *M. dubius frequens* and *Gothograptus nassa*. They are overlain by 50 cm of yellowish grey tuffite. The section is terminated by about 70 cm of dark thin-bedded shales of the *M. dubius frequens* and *G. nassa* Interregnum.

The Koněprusy Section is very similar to the Všeradice Section. Interesting is the change in the chitinozoan associations at the boundary between the *T. testis* Subzone and the *M. dubius parvus* Biozone. In the uppermost levels of the *T. testis* Subzone *Margachitina margaritana* and *?Urnochitina* sp. B disappear. *Eisenackitina branikensis* sp.n. occurs at the base of *M. dubius parvus* Biozone. Higher up, in the *M. dubius frequens – Gothograptus nassa* Interregnum, the association with *Eisenackitina branikensis*, *Conochitina tuba* and *Conochitina pachycephala* occurs. Close to the boundary between the *T. testis* Subzone and *M. dubius parvus* Biozone a similar crisis or change in the chitinozoan evolution may be seen as in the graptolites evolution registered by JAEGER (1991).



Text-Fig. 3.
Koněprusy Section (no. 781) near Koněprusy with fossil ranges.

4.3. The Pankrác Segment of the Prague Basin: Mládežnická Section, Motokov Section and Kavčí Hory Section

In most sections at the *C. lundgreni/M. dubius parvus* Biozone boundary intrusive basalt is developed in the Pankrác Segment. For this reason the sections below the boundary are described separately from the section above the boundary (Braník Section).

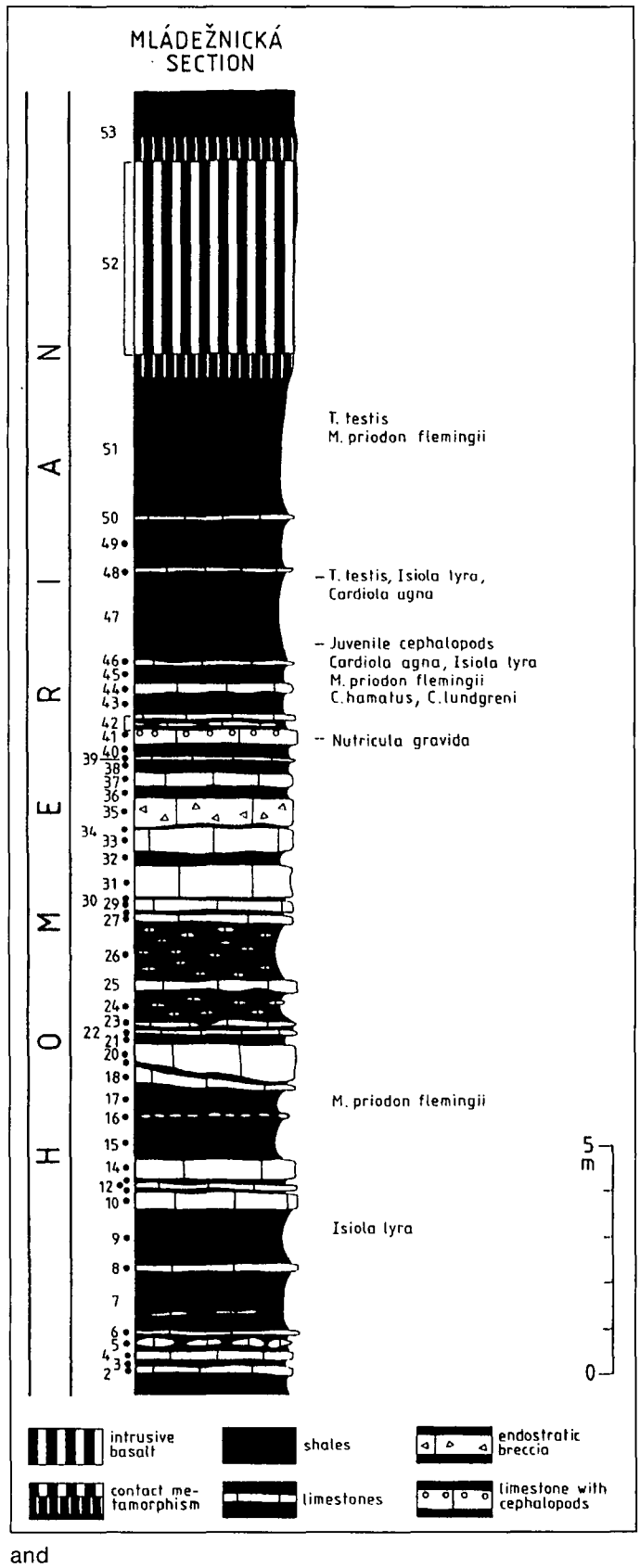
All three sections (Mládežnická Section – Text-Fig. 4, Motokov Section – Text-Fig. 5, and Kavčí Hory Section – Text-Fig. 6) were exposed only temporarily (1971, 1976 and 1970) and a more detailed collection was impossible. Here only the upper parts of the sections which correspond to the upper *M. testis* Subzone of the *C. lundgreni* Biozone are described.

In the middle parts of this biozone levels of grey micritic to bioclastic shallow water limestones are developed in all sections, locally with cross-bedding. Common to all sections is an endostratic breccia which can be of the same age. In the Motokov Section a level of effusive granulated basalt is developed above this breccia followed by synsedimentary slides of large parts of the limestone sequence. The endostratic breccia documents the development of irregularities and tremors of the bottom connected with volcanic activity prior to local effusion. In the Kavčí Hory Section (Text-Fig. 6) – above the endostratic breccia – a sequence of tuffaceous shales occurs with thin levels of tuffite and micritic limestone which is overlain by a level of cephalopod limestone with common nektobenthic cephalopods and the bivalve *Nutricula gravida*. Above it there is a level with nodules, containing abundant indeterminable cephalopods and bivalves. Grey granular limestone with *Aulacopleura konincki* follows containing fragments of tuffite and filling the spaces between the nodules with cephalopods. In the upper part of the limestone complex a lenticular level of fining-up granular limestone developed with common *M. priodon flemingii* in the lower part of the level. The sequence continues by 600 cm of grey brownish tuffaceous shales altered at the contact with the basalt intrusion in the upper part.

In the Motokov Section (Text-Fig. 5) about 250 cm thick shales with lenses and concretions of grey micritic limestone are developed above the breccia. Then tuffaceous limestones follow, altered in the upper part at the contact with the granulated basalt which overlies the sequence. Above the granulate are shales about 200 cm thick with large fragments of tuffaceous limestone identical in lithology with that below the granulate. Fragments of the same limestone are also enveloped by the granulate. The sequence continues by tuffaceous shales with tuffaceous limestone, tuffite and limestone with cephalopods and *M. priodon flemingii*, about 250 cm thick.

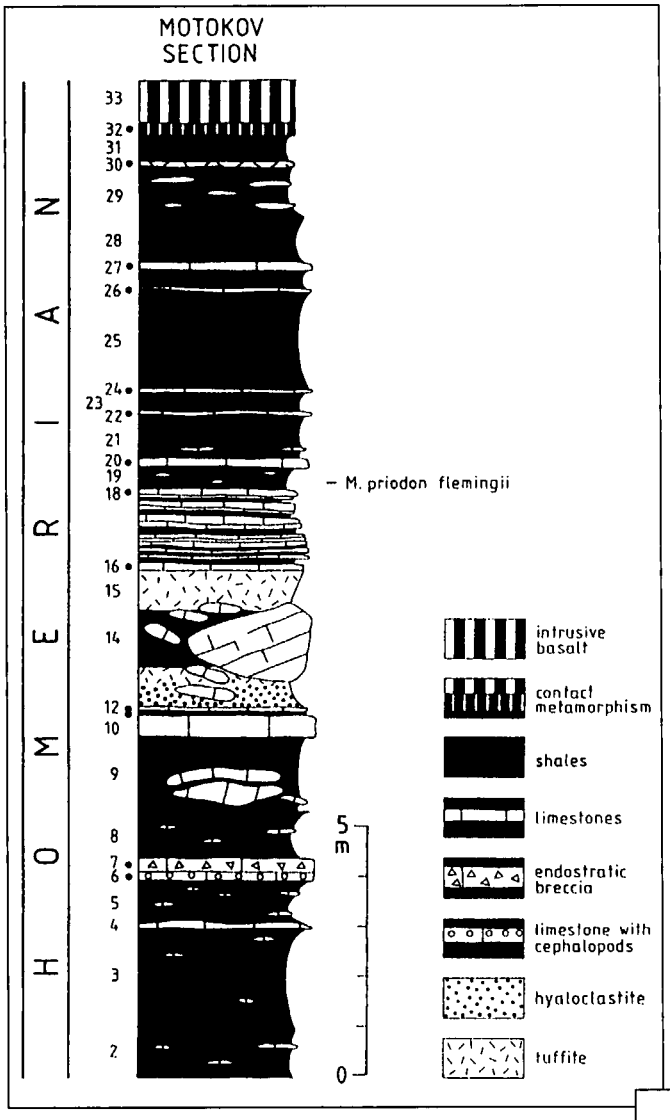
The section is terminated by a 700 cm thick sequence of dark calcareous shales with several levels of micritic limestones and common nodules of micritic limestone in the upper part, where also tuffite beds occur. The upper part of the sequence is overprinted by the intrusive basalt.

A similar situation was in the exposure of the underground station Mládežnická (Text-Fig. 4). Above the breccia is a sequence of tuffaceous grey calcareous shales alternating with grey laminated limestone and with cephalopod limestone in the upper part in which *Nutricula gravida* occurs. The section is terminated here too by a 800 cm thick sequence of dark grey calcareous shales with few levels of light grey micritic limestone without fossils. Between the levels no. 46



Text-Fig. 4.
Mládežnická Section in Praha-Pankrác with fossil ranges.

and



Text-Fig. 5.
Motokov Section in Praha-Pankrác with fossil ranges.

4.4. The Pankrác Segment of the Prague Basin: Braník Section – no. 764

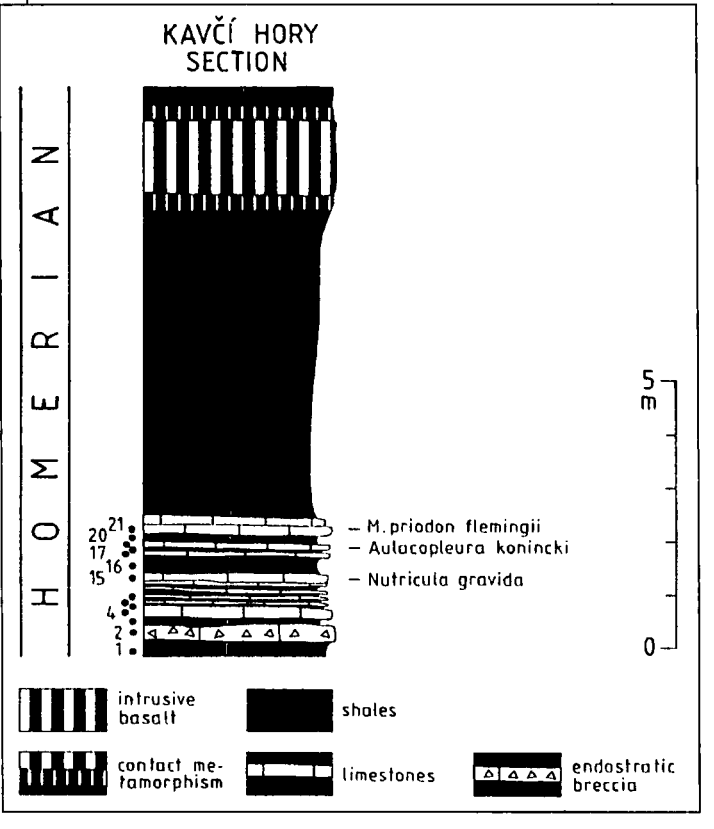
The Braník Section is situated north of the church of St. Prokop in Praha-Braník, south of the Braník Quarry (Text-Fig. 1, 7). The section was studied by J. Kříž in 1991.

The sequence starts by an intrusive sill of quartz-doleritic basalt. It is overlain by dark grey calcareous shales 30 cm thick, metamorphosed at the contact. It follows a large lens of grey micritic limestone with remains of the non-vascular plant *Prototaxites*. The lens is overlain by 70 cm of dark grey to dark calcareous shales with remains of *Prototaxites*, with the graptolites *M. dubius parvus* and *Gothograptus nassa*, the brachiopods *Strophochonetes zephyrus*, *Mezounia bicuspis*, *Ravozetina quaziprokopia*, *"Lingula" unguis*, *Giraldibella cognata*, *Bracteoleptaena bracteola* and *Lissatrypa* sp., the trilobite *Decoroproetus miser miser*, *"Plumulites" minimus* and *"Ortotheca" pulchra*.

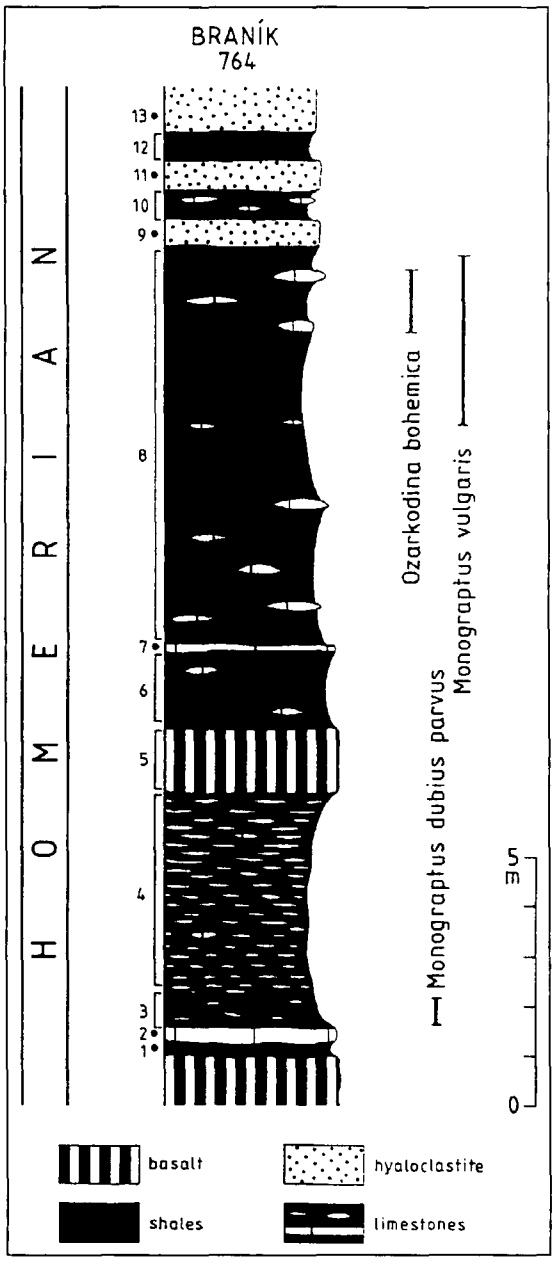
The sequence follows up by 400 cm of dark grey calcareous shales with common thin lenses of grey bioclastic limestones and relatively small concretions of dark grey micritic limestone. In the upper parts of this level and higher up *M. dubius frequens* occurs and the chitinozoans *Eisenackitina branikensis* sp.n., *Conochitina tuba*, *Conochitina pachycephala* and *Ancyrochitina* gr. *ancyrea*. This association is very similar to the association found at the Koněprusy Section in the *M. dubius frequens-Gothograptus nassa* Interregnum.

Next in the section is another sill of quartz-doleritic basalt overlain by 50 cm thick grey to grey brown tuffaceous shales with thin calcite veins and rare concre-

no. 48 in the shales rich fossils occur represented by juvenile pyritized cephalopods (KOLEBABA, 1973), the bivalves *Cardiola agna*, *Isiola lyra*, *Butovicella migrans*, and the graptolites *M. testis*, *C. hamatus* and *C. lundgreni*. In the shales about 100 cm below the intrusive basalt the graptolites *M. testis* and *M. priodon flemingii* and the bivalves *Cardiola agna* and *Isiola lyra* occur abundantly. The uppermost part of the section is metamorphosed by 420 cm thick intrusive basalts. The shales which overlay the basalts are at the base also metamorphosed. 350 cm above the basalt a lens of grey limestone is developed. In the shales below there are still common indeterminable graptolites and cephalopods corresponding most probably to the *M. testis* Subzone. About 450 cm higher in the shales a characteristic fauna of the *C. colonus* Zone occurs: *Bohemograptus bohemicus*, *M. dubius* s.l., deformed cephalopods, *Aptychopsis* sp. and *Ceratiocaris* sp.



Text-Fig. 6.
Kavčí Hory Section near Praha-Pankrác with fossil ranges.



Text-Fig. 7.
Braník Section (no. 764) in Praha-Braník with fossil ranges.

tions of dark grey micritic limestone with juvenile stages of *Cardiola*, gastropods and remains of the non-vascular plant *Pachytheca*.

This level is overlain by a 800 cm thick sequence of grey brown tuffaceous and calcareous shales with scattered larger concretions of dark grey micritic limestone. In the upper 200 cm the shales contain very commonly *M. vulgaris* and *M. dubius* s.l. Concretions in the upper part contain a rich association of cephalopods, the graptolites *M. vulgaris* and *M. dubius* s.l., the community of bivalves *Cardiola* aff. *agna*, *Butovicella migrans*, *Manulicula manulia*, *Lunulacardium* cf. *simplex*, *Hemicardium* aff. *baro* and *Slava* cf. *pelerina*. The non-vascular plant *Pachytheca* occurs too and juvenile gastropods.

The community has closest relationships to the *Cardiola agna* and *Cardiola gibbosa* Communities (KŘÍŽ, 1992).

Occurrences of conodonts are indicated in Text-Fig. 7. Most important is the proof of *Ozarkodina bohemica* (Pa and Pb elements) within the range of *Monograptus vulgaris* in limestone lenses within the upper part of level 8. In its lower portion *O. e. excavata* was found.

The upper part of the section is formed by granulated effusive basalts (60 cm thick) which are overlain by grey brown tuffaceous shales with lenses of grey tuffaceous limestone (60 cm thick). The top of the exposed section is formed by a hyaloclastite.

4.5. The Central Segment of the Prague Basin: Konvářka Section – No. 785

The Konvářka Section is located in the road cut of the U Divčích Hradů Street in Praha-Konvářka, above the Smíchov Railway Station (Text-Fig. 1). The section was studied by J. KŘÍŽ in 1991.

The section starts with 110 cm of brown tuffite with local admixture of crinoid detritus, thallophyts and fragmented brachiopods. Above several levels of endostratic breccia are developed which are overlain by two beds with nectobenthic cephalopods and the bivalves *Cardiola* aff. *gibbosa*, *Butovicella migrans*, *Slava* cf. *pelerina*, *Odontopleura* sp., *Plumulites* sp. and commonly *M. priodon flemingii*. Up to this level the section corresponds to the zone of *C. lundgreni*. The following 300 cm of the section are covered by the scree.

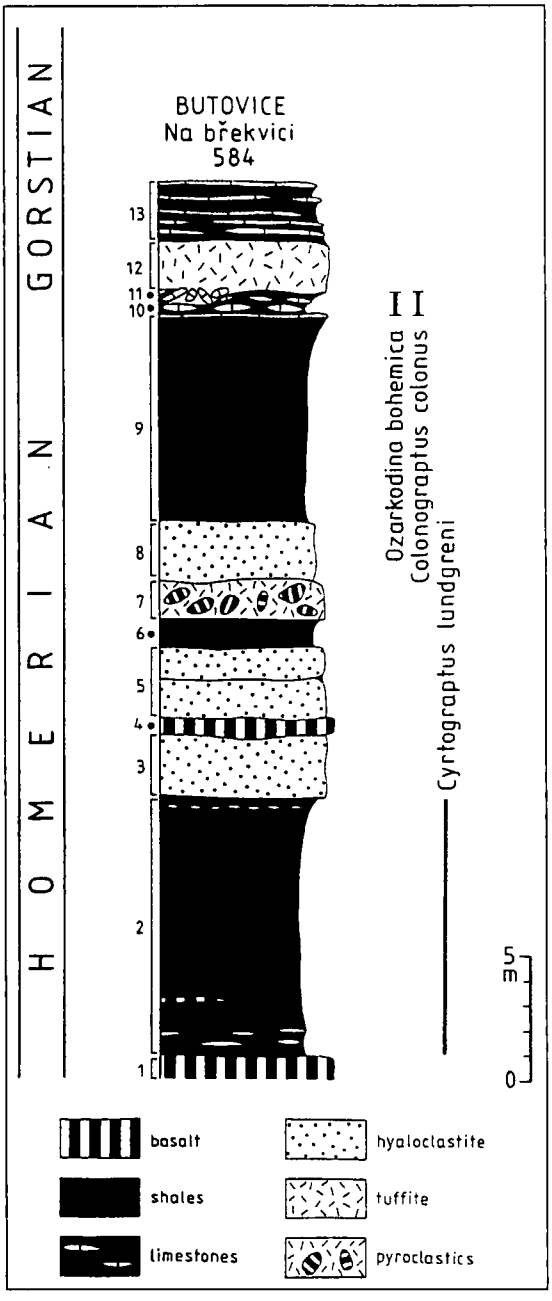
Further up the sequence continues with 130 cm thick yellow brownish tuffaceous shales with common bioclasts, fragments of brachiopods and trilobites. The brachiopod *Ravozetina* cf. *quaziprokopia* was determined. In the shales a 37 cm thick bed of brownish dark grey tuffite is developed which is more calcareous in its higher parts. It contains a characteristic fauna of the *M. dubius parvus* Biozone: the brachiopods *Ravozetina quaziprokopia*, *Orhoria amelia*, *Bracteoleptaena bracteola*, *Giraldibella cognata*, *Terazkia expandens*, *Araspirifer araneus*, *Miriospirifer dichotomus*, *Resserella canalis*, *Mezounia bicuspis*, *Septatrypa* sp. and the graptolite *Gothograptus nassa*. In the shales above *M. dubius* s.l. and *Gothograptus nassa* occur. The rest of the section is not exposed.

4.6. The Central Segment of the Prague Basin: Nová Ves Volcanic Centre, Butovice Section – No. 584

The section which is part of the Nová Ves Volcanic Centre is situated south of the Kační Quarry, south-west of Praha-Butovice (Text-Fig. 1, 8). The sequence starts by effusive basalts which are overlain by 1050 cm of dark grey calcareous shales with rare concretions of dark micritic limestone. In the shales the graptolites *C. lundgreni*, *Plectograptus praemacilentus* and *Monograptus* sp. and remains of the non-vascular plant *Prototaxites* occur. The decalcified laminae contain common juvenile stages of cephalopods, bivalves and disarticulated stem plates of crinoids. In the uppermost parts the chitinozoans *Ancyrochitina* gr. *ancyrea*, *Conochitina tuba* and *C. pachycephala* occur.

The section succeeds by about 1155 cm of hyaloclastite representing the north-east marginal part of the Nová Ves Volcanic Centre. Inside of the volcaniclastics a level of dark grey-green tuffitic shales is developed in which stratigraphically unimportant chitinozoans *Ancyrochitina* sp. and *Conochitina tuba* occur.

Above the volcaniclastics the sequence of dark brown grey-green tuffaceous shales is 870 cm thick. They contain in the uppermost part *Colonograptus colonus* and *Colonograptus roemeri* indicating the *C. colonus* Biozone. The sequence is terminated by a 7 cm thick bed of dark micritic limestone.



Text-Fig. 8.
Butovice Section (no. 584) in Praha-Butovice with fossil ranges.

It is overlain by a level of rusty-brown shales about 50 cm thick with two levels of concretions. The lower level contains relatively large concretions (up to 50 cm in diameter). Each concretion is represented in cross-section by two different lithologies. The lower half is formed by grey bioclastic limestone with common cephalopods and graptolites and the upper half is formed by dark-grey, micritic limestone with ontogenetic stages of bivalves and gastropods. In the upper level the concretions are smaller and are formed by dark-grey, micritic limestone with relatively rare graptolites and ontogenetic stages of *Cardiola gibbosa*.

Locally the nodules are accumulated and chaotically arranged due to sliding. The levels with concretions are overlain by a 200 cm thick coarse-grained tuffite. Where the concretions are chaotically arranged, part of the concretions is enveloped by tuffite (KŘÍŽ, 1961, 1962).

In the concretions a rich fauna of the *Cardiola gibbosa* Community (KŘÍŽ, 1992) occurs with dominant *Cardiola gibbosa* (37 %), *Manulicula manulia*, *Butovicella migrans*, *Cardiola contrastans*, *Slava bohemica*, *Maminka comata*, *Spanila* div.sp., *Slava decurtata*, *Isiola amplians*, *Slava pelerina*, *Lunulacardium* div.sp., *Cardiola agna*, *Modiolopsis senilis*, *Slava discrepans*, *Procarinaria zephyrina*, *Praeostrea bohemica*, *Dualina* div.sp., *Mila* div.sp., *Slavinka acuta*, nektobenthic cephalopods, e.g. most commonly *Protobactrites styloideum*, gastropods, monoplacophorids *Undicornu carens*, *Drahomira* sp., very rare brachiopods *Sufetirhynchia radvani*, *Septatrypa brekvice*, *Septatrypa lissodermis*, *Striispirifer* sp. and trilobites *Bumastus* sp.n., *Odontopleura ovata ovata* and *Kosovopeltis inopinata*, graptolites *Neodiversograptus nilssoni*, *Colonograptus colonus*, *Colonograptus roemeri*, *Bohemograptus bohemicus bohemicus*, *Monograptus uncinatus*, *Plectograptus macilentus*, a.o., and very commonly non-vascular plants *Prototaxites* and *Pachytheca*.

Conodonts from sample no. 10 yielded abundant representatives of *Ozarkodina bohemica* (Pa and Pb elements), *O. e. excavata* and *Kockelella variabilis*. These data well agree with the observation of WALLISER (1964) who also recorded *O. bohemica* from this section. His locality, however, was named "Jinonice". At the same horizon the index graptolite species *Colonograptus colonus* occurs (Text-Fig. 8).

The *Cardiola gibbosa* Community was adapted to the life in the cephalopod limestone biofacies. Epibyssate bivalves are most common (76 %). Local accumulation of articulated juveniles of bivalves and brachiopods indicate short periods of abiotic conditions.

4.7. The Central Segment of the Prague Basin: Nová Ves Volcanic Centre, Praha-Reporyje, Arethusina Gorge – No. 687

The section (KŘÍŽ, 1992) is part of the Nová Ves Volcanic Centre area. It starts in the Arethusina Gorge east of Praha-Řeporyje (Text-Fig. 1) and south of the Velká Ohrada Village, by shales of the *T. testis* Biozone which contain in the upper part lenses and levels of cephalopod limestone. In the shales *T. testis*, *Cyrtograptus hamatus*, *C. lundgreni*, *Monograptus priodon flemingii* a.o occur commonly. In the cephalopod limestone the *Cardiola agna* Community (= type locality, KŘÍŽ, 1993) occurs. It consists mainly of nektobenthic cephalopods and epibyssate bivalves: *Cardiola agna*, *Maminka* sp., *Slava fibrosa*, *Slava pelerina*, *Isiola lyra*, *Spanila* sp., *Butovicella migrans*, *"Cypricardinia"* sp., *Modiolopsis* sp., *Lunulacardium* sp., *Dualina* sp., *Praeostrea* cf. *bohemica*, *Slava discrepans*, *Procarinaria zephyrina*, rare brachiopod *Bleshidium papalas* and tabulates, the trilobite *Aulacopleura* sp. Very common are fragments of the non-vascular plants *Prototaxites* and *Pachytheca*, fragments of the graptolite *M. priodon flemingii* and juvenile bivalves, gastropods and cephalopods.

At this level *Ozarkodina sagitta sagitta* co-occurs with early representatives of *Ozarkodina bohemica*.

The sequence continues above the shales into basalts and volcaniclastics which represent the western part of the Nová Ves Volcanoes. The activity started here by the initial eruption and the subsequent degasation. At the base amygdaloidal basalt is developed followed by a tuffoagglomerate. Above there are granulated spilitized basalt pillow-lavas and the sequence ends by volcaniclastics with tuff intercalations. The overall thickness of the volcaniclastics and basalts is about 45 m.

The volcaniclastics are overlain by a sequence of brown-grey tuffitic shales alternating with lenses and concretions of grey fine-grained limestone (5–10 cm thick, exceptionally 25 cm thick).

The trilobite spcies *Cromus storchi* was found about 270 cm above the base. The first graptolites were found 100 cm higher and the species *Bohemograptus bohemicus bohemicus, Colonograptus colonus, Monograptus chimaera semispinosus, Spinograptus spinosus, M. scanicus, Dendrograptus (S.) fruticosus* indicate the *M. chimaera* Biozone.

The limestone lenses are more fossiliferous immediately in front of the Mušlovka Quarry and in the quarry below the thick bed (layer no. 1/2). In the lenses the trilobites *Encrinuraspis beaumonti, Eophacops bulliceps, Otrarion (O.) diffractum, Balizoma transiens, Diacanthaspis (Acanthalomina) minuta, Bohemoharpes (B.) ovatum, Leonaspis geinitziana, Didrepanon squarrosum, Sphaerexochus paramirus* a.o. occur, the brachiopods *Bleshidium patellinum, Agarhyncha famula, Dubaria saphina, Leptostrophiella nebulosa, Cadudium sphaeruleum, Bleshidium paucicosta, Xeniopugnax modicus, Gracianella umbrella, Claratrypa clarula, Septatrypa alumna, Septatrypa caprilupa, Septatrypa sapho, Dubaria megaera, Cromatrypa orbis, C. pentagona, Atrypoidea linguata, Protozeuga miliana, Pseudoprotathyris daeles, Cyrtia bedya bedya, Cyrtia humilis, Tenellodermis tenellus, Alaskospira carens, Spirinella tureki*, a.o., the bivalves *Cardiola docens, Cardiola consanguis, Slava cubicula, Butovicella migrans, Slavinka tanita, S. amarygma, S. elevata, Spanila* div. sp., *Dualina* div. sp., common cephalopods, the graptolites *Bohemograptus bohemicus bohemicus* and *Monograptus fritschi linearis*, a.o. HAVLÍČEK & ŠTORCH (1991) described this assemblage as the *Encrinuraspis beaumonti*-smooth Atrypid Community and suggested that it occupied the Benthic Assemblage 3–4 life zone.

The overall thickness of the *M. chimaera* and *M. fritschi linearis* Biozones is about 35 m.

4.8. The Northern Segment of the Prague Basin: Lištice Section – No. 770, Lištice Pipeline Section – No. 579

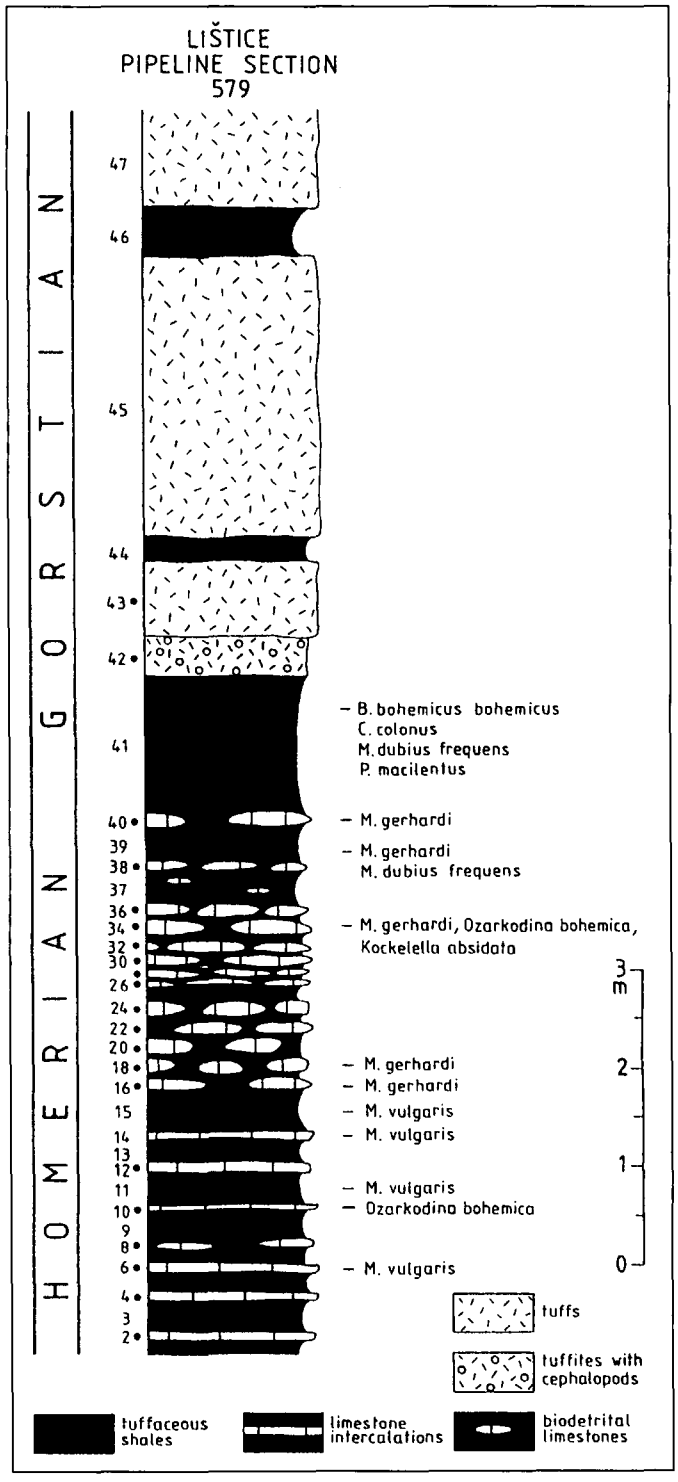
The sections are exposed in the Beroun-Lištice Village (Text-Fig. 1). The sequence is not continuous but since the sections no. 770 and 579 are close to each other it is possible to present them as one composite section.

The section no. 770, 25 m north-east of the house no. 725/14 in Beroun-Lištice starts by intrusive basalt which is overlain by about 180 cm thick calcareous grey tuffaceous shales. They contain in lower parts (about 123 cm) the graptolites *M. dubius parvus, Gothograptus nassa*, the brachiopods *Aulacatrypa squama, Bracteoleptaena bracteola, Lissatrypa* sp., *Strophochonetes zephyrus, Ravozetina quasiprokopia, Giraldibella cognata, Mezounia* sp., *Bleshidium papalas, Jonesea myrmido, "Lingula" unguis*, the trilobites *Rabuloproetus borekensis, Decoroproetus miser miser, Raphiophorus roualti, Delops? orbus, Miraspis simara, Odontopleura* cf. *betina, "Plumulites" minimus, "Ortotheca" pulchra*, the conodont subspecies *Ozarkodina sagitta rhenana* and the non-vascular plants *Pachytheca* sp. and *Prototaxites* sp. In higher parts the graptolites *M. dubius frequens* and *G. nassa* occur which indicate the *M. dubius frequens-G. nassa* Interregnum.

The shales are overlain by more than 150 cm of grey-green tuffites with rare nodules of dark grey micritic limestone in the lower part which contain *Bracteoleptaena bracteola, Delops? orbus* a.o.

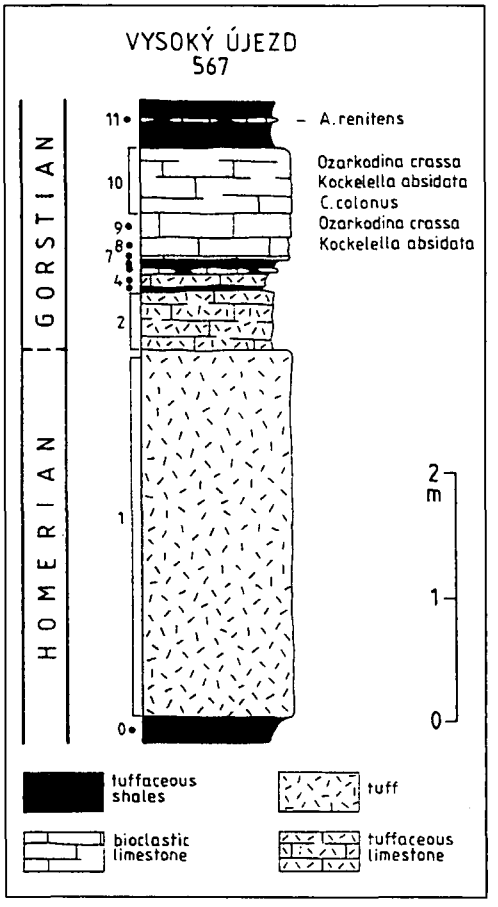
The sequence continues by granulated basalts and tuffs, which are exposed on the north-eastern side of Beroun-Lištice in an abandoned quarry. The basalts and tuffs are overlain by tuffaceous shales which were exposed temporarily during the pipeline construction north east of Beroun-Lištice in the section no. 579 (Text-Fig. 9).

This section starts by a 275 cm thick sequence of grey brownish tuffaceous shales with more calcareous to limestone levels. In the shales a mass occurrence of *M. vulgaris* and of the non-vascular plant *Prototaxites* was recorded.



Text-Fig. 9.
Lištice Pipeline Section (no. 579) near Beroun with fossil ranges.

Text-Fig. 10.
Vysoký Újezd Section (no. 567) near Vysoký Újezd with fossil ranges.



Higher up the 275 cm of tuffaceous shales contain large nodules and lenses of grey micritic to biodetrital limestone with common brachiopods *Indaclor sulcicarens, Gypidula vestita, Strophoprion euglypha, Ravozetina quasiprokopia, Striispirifer viator, Miriospirifer* cf. *dichotomus, Janius nobilis, Lissatrypa fumida, Tenellodermis elatus, Leptostrophiella nebulosa, Meristina mora, Amphistrophiella standinia, Atrypa fumosa, Leangella tufogena, Septatrypa alumna, Isorthis (Arcualla) manon, Dicoelosia* sp., *Gotatrypa* sp., *Orhoria* cf. *orhor, Bleshidium* sp., *Kirkidium (P.) bohemicum, Cyrtia* cf. *ludlowensis, Cyrtia* sp.n., *Dalejina* sp., *Resserella* sp., *Dionaegiria* sp., the trilobites *Cheirurus (Ch.) insignis, Odontopleura prevosti* ssp., *Otarion (O.)* aff. *verrucosum, Interproetus* cf. *clarimonda, Richterarges* cf. *ambiguus, Eophacops* sp., the bivalves *Cardiola contrastans, C.* aff. *gibbosa*, gastropods, fragments of cephalopods, and the conodonts *Ozarkodina e. excavata, Kockelella absidata* and *O. bohemica* (Text-Fig. 9), the non-vascular plant *Prototaxites* sp. and corals. The occurrence of the graptolites *M. gerhardi* and *M. dubius frequens* indicates the upper levels of the *M. vulgaris* Biozone. This level with limestones corresponds to the uplift which increased the role of volcanic accumulations prior to the *M. vulgaris* Biozone during the global regression.

The sequence continues by 137 cm of grey brown shales with tuffitic laminae which contain graptolites of the *C. colonus* Biozone: *C. colonus, M. dubius frequens, B. bohemicus bohemicus, Plectograptus macilentus* and dendroids. Higher up are coarse grey-greenish brown calcareous tuffites with common nektobenthic cephalopods oriented by current in NE–SW direction. Above tuffites with cephalopods are 75 cm of grey greenish massive tuff overlain by rusty brown tuffaceous shales to tuffites followed by 280 cm thick massive rusty brown tuffs. They are succeeded by 50 cm of rusty brown tuffaceous shales follow and more than 100 cm of massive greenish grey coarse-grained tuff.

4.9. The Northern Segment of the Prague Basin: Hačka Section – No. 758, Vysoký Újezd Section – No. 567

The section no. 758 WNW of Vysoký Újezd is situated between the Hačka Hill and Kolo Hill and starts by a basalt intrusion. Above the intrusion there are about 50 cm of calcareous grey brown shales with bioclasts and large fragments of volcanic glass and with the brachiopods *Ravozetina quasiprokopia, Strophochonetes zephyrus, Giraldibella cognata, "Lingula" unguis, Salopina accedens, Craniops nana, Bracteoleptaena bracteola, Mezounia bicuspis, Bleshidium* cf. *papalas, Lissatrypa* cf. *cibia, Pseudoprotathyris* sp., the trilobites *Delops*? *orbus, Radnoria* sp.n., *Odontopleura* sp., *Raphiophorus roualti, Rabuloproetus borekensis, "Plumulites" minimus, "Ortotheca" pulchra, Kolihaia eremita*, non-vascular plants *Pachytheca* sp. and *Prototaxites* sp., and graptolites *M. dubius parvus, G. nassa*. The horizon corresponds to the *M. dubius parvus* Biozone.

The level is overlain by grey calcareous shales with graptolites of the *M. dubius frequens – G. nassa* Biozone.

The section no. 567 is exposed more eastward on the truck road NW of the Vysoký Újezd Village (Text-Fig. 1, 10). Between the section no. 758 and no. 567 are most probably volcanites and volcaniclastics. The section no. 567 starts by grey greenish tuffaceous shales which are overlain by 295 cm of grey greenish coarse tuffs. Higher up there is a sequence of weathered light-yellow and greenish-yellow tuffaceous limestones. It is followed by a 90 cm thick bed of grey biomicritic to biodetrital limestone follows which contains the brachiopods *Indaclor sulcicarens* (dominant), *Septatrypa caprilupa, Leangella tufogena, Cadudium* sp., *Cyrtia ludlowensis, Gotatrypa* sp., *Orhoria orhor, Bleshidium paucicosta, Skenidioides* sp., *Orbiculoidea* sp., *Macropleura* sp., *Resserella* sp., *Conchidium* sp., *Spirinella tureki, "Lingulella"* sp., *Janius* cf. *nobilis, Stenorhynchia* sp., *Anastrophia deflexa, Macropleura reluctans, Ravozetina* sp., *Eospinatrypa* sp., *Antirhynchonella* sp., *Tenellodermis* sp., *Schizotreta* sp., *Striispirifer viator, Dyctionella bohemica, Lissatrypa fumida, Gracianella umbrella, Dolerorthis kopaninensis* a.o., the trilobites *Interproetus soncobrinus, I.* cf. *consobrinus, I.* sp.n., *Odontopleura ovata ovata, Scharyia wenlockiana, Ktenoura oronapi, Kosovopeltis* aff. *inopinata, Eophacops alter, Coniproetus (Ryckholtia)* sp.n., *Conoparia clarimonda, Tropidocoryphe*? *praecurrens, Dicranopeltis scabra, Bumastus* sp.n., *Harpidella* sp., *Otarion* aff. *verrucosum, Selenopeltoides hawlei, Bohemoharpes* sp., the gastropodes and monoplacophorids *Undicornu* aff. *carens, Temnodiscus cristatus, Tropidodiscus* sp.n., *Kodymites vulcanus, Prosoptychus* cf. *globulus, Lytospira* sp., *Euomphalopterus* sp., *Murchisonia (Sinuspira) tenera, Spirina patula, Spirina* cf. *tubicina*, the bivalves *Cardiola agna, Butovicella migrans, Manulicula manulia, Rhombopteria* aff. *mira, Lunulacardium emaciatum, Maminka comata, Slava bohemica, S. pelerina, "Pterinea" cf. cometula, Maminka tenax, Cardiola contrastans, Lunulacardium initians, "Modiolopsis"* aff. *tenera, "Modiolopsis" senilis, "Mytilarca" rara, Spanila* cf. *culter, "Astarte" composita, Spanila cardiopsis*, fragments of nektobenthic cephalopods, the non-vascular plant *Prototaxites* sp. and the graptolite *Colonograptus colonus* indicating the *Colonograptus colonus* Biozone.

The 90 cm thick limestones with cephalopods contain such conodonts like *Ozarkodina crassa, O. e. excavata, Kockelella variabilis* and *K. absidata* (Text-Fig. 10). Yet, no representative of *O. bohemica* has been found at this level corresponding to the base of the *C. colonus* graptolite biozone.

The top of the sequence is formed by rusty brown tuffaceous shales with lenses of grey-brown micritic limestone with *Atrypoidea renitens*, *Tenellodermis* sp., *Septatrypa caprilupa*, *Gracianella* sp., *Gipidula* sp., *Orhoria* sp. and *Atrypina inops*.

4.10. The Central Segment of the Prague Basin: Svatý Jan Volcanic Centre, Lištice – No. 759,

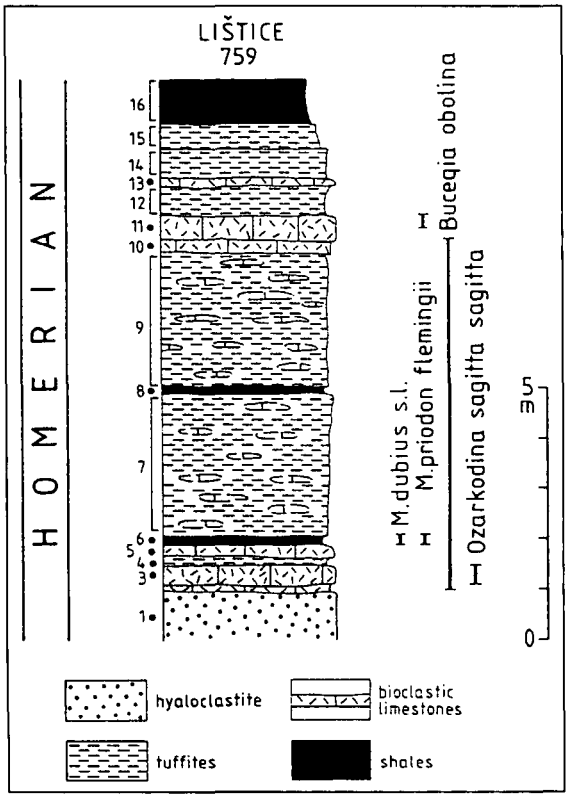
The section no. 759 (Figs. 1,11) was in general described and discussed by HORNÝ (1955, 1962 and 1971). It starts above the path south of the quarry in the volcaniclastics, south-west of Beroun-Lištice. The volcaniclastics are overlain by lenses of grey micritic limestone (no. 3) with crinoid detritus, volcanic glass and the *Buceqia obolina* Community. Besides dominant brachiopod species the community contains the brachiopods *Cryptatrypa philomella*, *Bleshidium papalas*, *Aratoechia minerva*, *Hircinisca* cf. *rhynchonelliformis*, *Striispirifer aurelius*, the trilobites *Cheirurus obtusatus*, *Kosovopeltis inopinata*, *Odontopleura prevosti prevosti*, *Aulacopleura konincki*, the bivalves *"Nucula" simplicitor*, *Butovicella migrans*, *Isiola lyra*, *Slava* cf. *pelerina*, *Cardiola* aff. *agna*, orthocone cephalopods and the conodont *Ozarkodina sagitta sagitta*. Diversified acritarchs and rare spors occur. Only long ranging species of the chitinozoans *Ancyrochitina ancyrea* and *Conochitina tuba* which are characteristic for the upper Wenlock and lower Ludlow of the Prague Basin were observed.

The limestone is overlain by 15 cm of greenish-grey tuffite (no. 4). It is followed by another layer of grey limestone (no. 5) and the layer of greenish-grey tuffitic shales (no. 6) with the graptolites *Monograptus dubius* s.l. and *M. priodon flemingii*, the brachiopod *Buceqia obolina*, the trilobite *Cheirurus obtusatus* and the nonvascular plant *Prototaxites* sp.

The section continues by 560 cm of grey-green coarse-grained tuffites with lenses of grey bioclastic crinoidal limestones (no. 7–no. 9) with the *Buceqia obolina* Community. The sequence of tuffites is overlain by a 70 cm thick layer of massive grey limestone (no. 10–no. 11) which in the uppermost level contains large rhabdosomes of *M. priodon flemingii*.

At this level (no. 10) *Ozarkodina* ex. *excavata* and *Kockelella absidata* occur.

About 300 cm of tuffitic shales, tuffites and tuffs in exposed parts of the sequence (no. 12–16) follow.



Text-Fig. 11.
Lištice Section (no. 759) near Beroun with fossil ranges.

4.10.1. U Drdů Section – No. 760

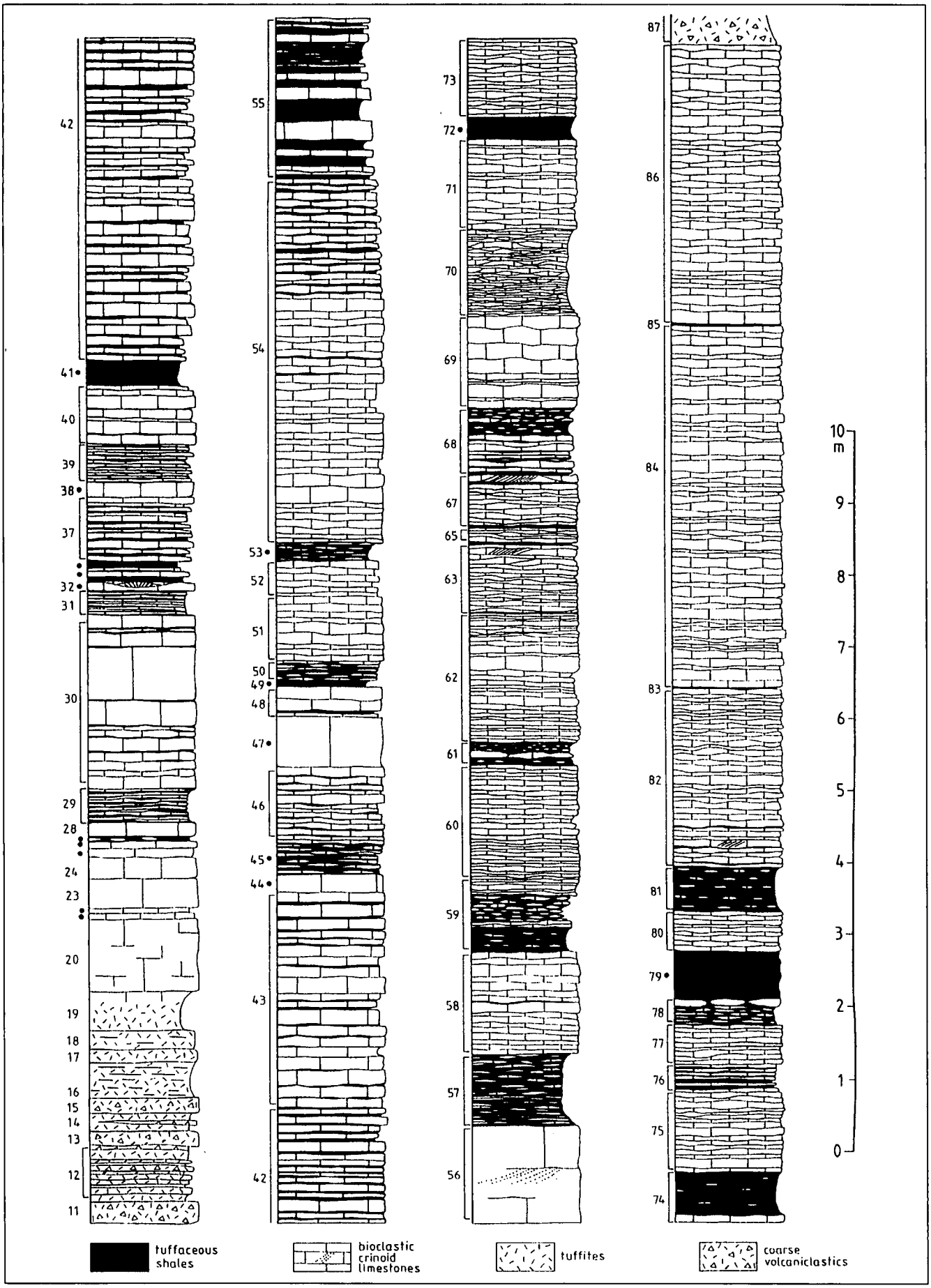
The section no. 760 (Figs. 1, 12) starts approximately 38 m of real thickness above the section no. 759 by a sequence of volcaniclastics and granulates in the lower part and alternating greenish more and less massive tuffites with lapilli and fragments of lava in the upper part (nos. 1–19). In the past the section was described by KODYM, BOUČEK & ŠULC (1931), by HAVLÍČEK, HORNÝ, CHLUPÁČ & ŠNAJDR (1958), by HORNÝ (1955, 1962, 1965, 1971), KUKAL (1955) and KŘÍŽ (1991).

The volcaniclastics transitionally pass into a sequence of crinoidal limestones with tuffite levels. Most fossiliferous are the lower limestone layers no. 24 and no. 25. They contain a brachiopod community with dominant *Mendacella venustula*, *Resserella canalis*, *Isorthis (A.) cliens*, *Rhynchotreta cunicula*, *Anastrophia deflexa*, *Cyrtia spiriferoides*, *Rufispirifer nucula*, *Protomegastrophia miranda*, *Striispirifer aurelius*, *Atrypa margarita*, *Nucleospira lentilca*, *Whitfieldella ypsilon*, *Kozlenia kozlensis*, *Atrypina paulula*, *Eospirifer praesecans*, *Amphistrophia harperi*, *Dicoelosia* sp., *Strophochonetes gluma*, *Skenidioides* sp., *rostroconch Conocardium* sp., the trilobite *Harpidella hama*, the corals *Heliolites decipiens*, *H. irregularis*, *H. bohemicus*, *H. spongoides*, *Helioplasmolites wentzeli*, *Stelliporella lamellata*, *Propora poctai*, *Favosites fidelis*, *F. gotlandicus*, *F. forbesi*, *Halysites catenularia*, *"Barrandeolites" bowerbanki*, *Entelophyllum confusum*, *E. prosperum*, stromatoporoids, bryozoans, a.o.

Higher the section consists of massive lenticular grey tuffitic bioclastic crinoidal limestone with levels of brown tuffites with small lenses of grey bioclastic crinoidal tuffitic limestones. The massive limestones show at some levels cross-bedding and silicification. In levels with tuffites a graded bedding may be seen. At the base of the thin layers lapilli, volcanic glass and coarse crinoidal detritus are concentrated which is fining up (KUKAL, 1955). In the uppermost 11 m of the section limestones are prevailing and tuffitic layers are almost missing. The fauna consists mostly of corals and stromatoporoids. On top of level no. 60 the brachiopods *Meristina mora*, *Resserella canalis*, *Atrypa margarita*, *Strophoprion euglypha*, *Leptostrophiella nebulosa*, *Shagamella margarita*, *Cyrtia spiriferoides*, *Isortis (Arcuala) cliens* and *Protomegastrophia miranda*, the trilobites *Proetus kopaninensis*, *Tropidocoryphe? praecurrens*, *Interproetus* sp., *Eophacops trapeziceps*, *Richterarges* sp.n.aff. *ambiguus* and *Cheirurus obtusatus* and stromatoporoids have been found.

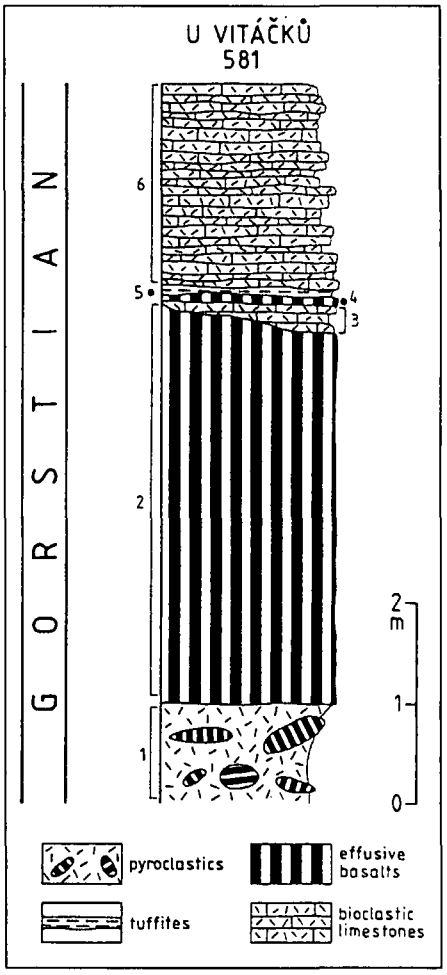
The conodont fauna from sample levels 24, 28, 30, 40 top, 70 bottom, 73 bottom, 82 top, 86 centre and 86 top all contain a uniform fauna characterized by *Ozarkodina bohemica*.

Tuffaceous limestones and shales contain common trilete miospores and cryptospores of early land plants. The diversity, density and mode preservation vary in different samples and the number of individual spores per slide is 15 to 20 times higher than the



Text-Fig. 12.
U Drdů Section (no. 760) near Beroun with fossil ranges.

Text-Fig. 13.
U Vitáčků Section (no. 581) near Beroun.



amount of the individuals of the phytoplankton-acritarchs. The assemblage of the sporomorphs is characteristic for the sporomorph zone cf. *protophanus – verrucatus* which was established for the upper Homerian and lower Gorstian (RICHARDSON and MCGREGOR, 1986). From the type region of Wenlock, Shropshire, England, BURGESS & RICHARDSON (1991) described an assemblage of miospores and cryptospores with almost the same species as found in the Lištice Section. The assemblage from Shropshire is dated as upper *C. lundgreni* Biozone up to the *M. vulgaris (M. ludensis)* Biozone. This observation by DUFKA (KŘÍŽ, 1992) represents another evidence for the dry land conditions on top of the Svatý Jan Volcanoe emerged during the uppermost Wenlock.

The overall thickness of the limestone complex called also "Kozel" limestone complex is 63 m. Laterally the thickness is changing very quickly. On the other side of the Berounka River Valley 400 m to the south-west the thickness of the limestone complex is only 14 m. According to brachiopod and trilobite fauna the age of the limestones is uppermost Wenlock. The last graptolite found below the complex on top of the section no. 759 is the graptolite *M. priodon flemingii*. The highest occurrence of this graptolite was recorded in the *C. lundgreni* Biozone. The age of the limestone complex could thus correspond only to the period between the *M. dubius parvus* Biozone and the *M. vulgaris* Biozone.

Another evidence for the age of the "Kozel" limestone complex represents the development of the nearby Lištice no. 579 section in the Northern Segment (Text-Fig. 16). Here the sedimentation of carbonates starts in the middle levels of the *M. vulgaris* Biozone as the result of uplift during the global regression the role of which was increased in the Central Segment and in the nearby Northern Segment by local accumulations of volcanics during the volcanic activity of the Svatý Jan Volcanic Centre in the period between the *M. dubius parvus* Biozone and *M. deubeli* Biozone.

4.10.2. U Vitáčků Section – No. 581

The section "U Vitáčků" is on the left side of the Berounka River and 350 m SES of the U Drdů Section (Text-Fig. 1, 13).

Exposed here is the top of the volcaniclastic complex (no. 1). It is overlain by 400 cm thick effusive basalts (no. 2) with calcitic amygdales. On the top of the basalt is developed grey bioclastic limestone (no. 3) with brachiopods and corals, some of them found directly attached on the basalt hard-ground. The fauna consists mainly of the brachiopods *"Oglupes"* sp., *Meristina mora, Leptaena odeon, Leptostrophiella nebulosa, Amphistrophiella standinia, Strophoprion euglypha, Howellella crispina, Janius bouskai, Hebetoechia sphaerulea, Isorthis (Arcualla)* sp., the trilobites *Odontopleura prevosti neumanni, Cheirurus obtusatus, Aulacopleura* sp., *Bumastus bouchardi* var.nov., *Sphaerexochus paramirus, Eophacops* sp., the corals *Heliolites* sp., *Halysites* cf. *catenularia* and large crinoids.

Yet, two conodont samples from levels 3 and 5 did not produce any significant results.

The fauna has closest relationships to the lower parts of the horizon with *C. beaumonti*, Gorstian, Ludlow in the Amerika Anticline and with the lower parts of the Kopanina Formation at the Kosov Quarry. Volcaniclastics below the limestones may thus correspond to the maximum eruptions in the Svatý Jan Volcanic Centre in the uppermost Wenlock and lowermost Ludlow, and approximately correspond to the maximum of volcanic activity in the Kosov Volcanic Centre and Nová Ves Volcanic Centre.

The limestones with brachiopods are overlain by a sequence of grey bioclastic crinoidal limestones (no. 6 – exposed sequence 450 cm).

The section is equivalent to the section at the other side of the Berounka River. It is first represented by the limestone complex "Kozel", which is only 14 m thick and overlain by 200 m of coarse volcaniclastics. The Pod Tetínem Section (no. 573) starts above by 22 m thick effusive basalts with calcitic amygdales. It is overlain by 0–32 cm thick greenish-grey tuffaceous crinoidal limestone which fills the irregularities in the surface of the basalt. At the base flat colonies of stromatoporoids and corals are developed, accompanied by large indeterminable atrypids, *Meristina mora* and *Kirkidium (Pinguaella)* sp. Higher up the brachiopods are more common. 80 cm of rusty, dark reddish tuffites follow with 1 to 10 cm thick lenses of fine-grained tuffaceous limestones with the brachiopods *Hebetoechia* sp., *Leptaena odeon, Leptostrophiella* cf. *nebulosa, Oglupes scarabeus, Meristina mora, Strophoprion euglyphus relata, Mesopholidostrophia papyracea, Isorthis (Arcualla)* sp., *Kozlenia* sp., the trilobite *Calymene desmoder*, and indetermined ostracodes.

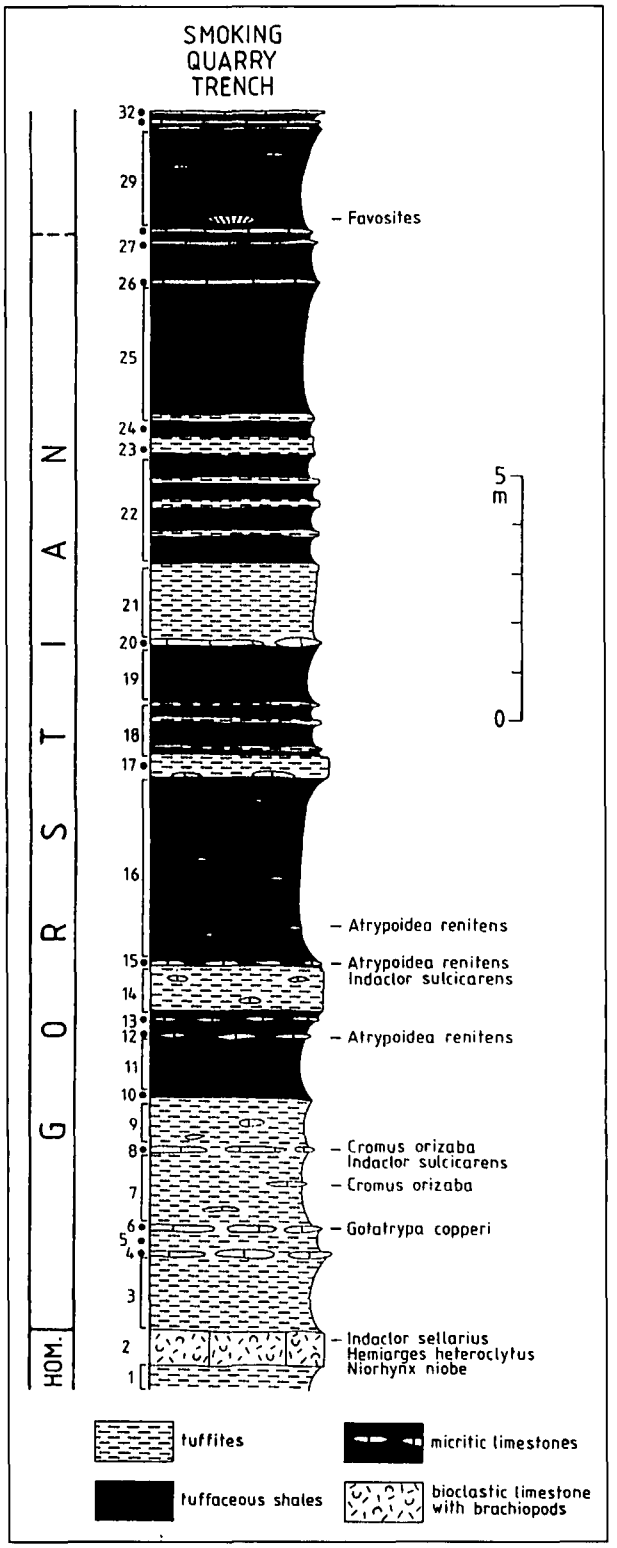
The next level is up to 20 cm thick and is formed by tuffaceous limestone with very abundant lapilli and rare large brachiopods (*Meristina mora*). The upper

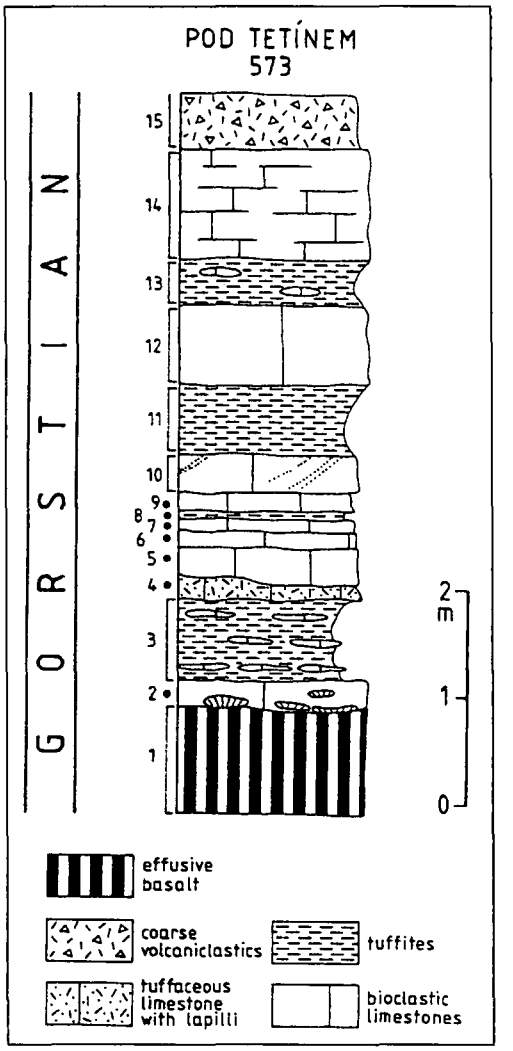
4.11. The Central Segment of the Prague Basin: Svatý Jan Volcanic Centre, Pod Tetínem Section – No. 573

The section is located in the railway cut below the Tetín Village, south-west of Beroun (Text-Fig. 1, 14). It was studied by HORNÝ (1955c, 1971) and in detail by J. KŘÍŽ in 1989.

Text-Fig. 14.
Pod Tetínem Section (no. 573) near Beroun.

part of the sequence is formed by 390 cm thick, thick-bedded, grey, biodetrital to tuffaceous, crinoidal limestones with rare intercalations of tuffite. In higher parts a level (no. 13) of rusty brown tuffites with lenses of crinoidal limestones is developed. The whole section corresponds according to the brachiopod fauna to the lower Ludlow (presence of the brachiopods *Hebetoechia* sp., *Leptostrophiella* cf. *nebulosa* and *Mesopholidostrophia papyracea*).





The sequence of limestones is overlain by 35 m thick coarse volcaniclastics. On top of them there is a sheet of effusive basalt, about 10 m thick, with calcitic amygdales. The basalt is overlain by 20.5 m of the Požáry Formation, Přídolí.

4.12. The Central Segment of the Prague Basin, Kozolupy, Smoking Quarry Section-Trench

The sequence was exposed in an artificial trench east of the abandoned quarry near the road from Mořina to Bubovice, north west of the "Amerika" Quarry (Text-Fig. 1, 15).

The oldest rocks exposed in the trench are represented by a sequence of brown tuffites several metres thick. They are overlain by almost 1 m of light rusty brown to grey bioclastic, crinoidal limestones (no. 2) with abundant brachiopods *Indaclor sellarius, Septatrypa lissodermis, Aratoechia arabella, Atrypina paulula, Lissatrypa cibia, Kozlenia pirola, Cyrtia spiriferoides, Cyrtia maior maior, Mendacella venustula, Niorhynx niobe, Eospirifer pollens, Janius nobilis, Spurispirifer* cf. *spurius, Sufetirhyncha radvani* a.o., the trilobites *Otarion (Conoparia) clarimonda, Interproetus soncobrinus, Ktenoura oronapi, Hemiarges heteroclytus, Eophacops alter, Dicranopeltis scabra propinqua, Cheirurus* sp., indet. bivalves, bryozoans and diverse corals. HAVLÍČEK & ŠTORCH (1990) defined the assemblage as the *Septatrypa lissodermis-Cyrtia maior* Community. It can be inter-

Text-Fig. 15.
Smoking Quarry Section-Trench, near Kozolupy with fossil ranges.

preted as the Benthic Assemblage 3 life zone. In the test pit described by HORNÝ (1955) which was situated more to the east, the overall thickness of the layer was approximately 5 m. According to the fauna this level is uppermost Wenlock in age.

The next 11.5 m (layers no. 3 to 16) are represented by a sequence of yellow to brown-grey tuffites to tuffitic shales with several levels of concretions to lenses of grey-greenish to brown-grey biomicritic to bioclastic tuffitic limestones with the common trilobites *Cromus orizaba* and *Balizoma transiens*, the brachiopods *Atrypoidea renitens, Septatrypa sulciplicata, Indaclor sulcicarens, Gotatrypa copperi, Atrypinella fuxina, Gracianella crista, Tenellodermis elatus, Dalejina ambigena, Sufetirhyncha radvani, Dicoelesia* sp. a.o. HAVLÍČEK & ŠTORCH (1990) defined this association as the *Atrypoidea renitens* Community and postulated for it a Benthic Assemblage 3 life position. The fauna corresponds to the fauna of the *M. chimaera* Zone

About 10.5 m of brown to yellow-brown tuffites to grey tuffitic shales without fossils follow.

The top of the sequence in the trench is represented by 2 m of brownish calcareous tuffitic shales alternating with lenses and concretions of brown to brown-grey biomicritic to bioclastic limestones. In the shales occur rarely colonies of tabulates. This part of the sequence corresponds to the horizon with *Cromus beaumonti* which is best exposed in the near Smoking Quarry.

4.13. The Central Segment of the Prague Basin: Tachlovice, Prostřední Mill Section – No. 713

The section is situated on the left side of the Radotín Brook, about 145 m north of the pond dam near the Prostřední Mill.

It starts with a sequence of brown tuffites and tuffaceous limestones which contain a characteristic fauna of the *T. testis* Biozone with *M. priodon flemingii*. From the locality M. ŠNAJDR described in several papers the trilobites *Odontopleura ovata ovata, Odontopleura rataji, Kosovopeltis inopinata, Ceratocephala verneuili, Ktenoura aravaka, Dicranopeltis scabra propinqua, Scharyia wenlockiana, Delops* sp., *Raphiophorus roualti, Eophacops bulliceps* subsp., *Proetus kopaninensis, Interproetus xenon, I. susy, I. albon, I. pralux, I numvertus, Decoroproetus miser knemix, Conoparia* sp. and *Cyphoproetus putzkeri hedvicaki*. He interpreted the age of the trilobites as the boundary rocks between the Motol Formation and Kopanina Formation.

Apart from the trilobites indeterminable cephalopods occur, the common non-vascular plant *Prototaxites*, the bivalve *Cardiola* aff. *agna* and the brachiopods *Placotriplesia moerra, Orhoria orhor, Strophoprion* sp., *Indaclor sellarius, Strophochonetes zephyrus, Gypidula* sp., *Cadudium* sp., *Rhynchotreta cunicula, Septatrypa conjunctus* and *Atrypa margarita*.

The section continues by 33 m of brown tuffaceous shales with brown and grey tuffaceous limestone levels with rare fragments of brachiopods and crinoidal detritus. 13 m of the section are covered. The uppermost part comprises about 20 m of grey, tuffaceous, fine-grained, thick-bedded limestones intercalated in brown, yellowish-brown to grey-brown, tuffaceous shales.

The fauna is equivalent to the facies which is exposed near Kozolupy in the Smoking Quarry and corresponds to the horizon with *Cromus beaumonti*.

4.14. The Western Segment of the Prague Basin: Kosov Volcanic Centre, Kosov Quarry Section – No. 767 and No. 776

The section is exposed in the Kosov Quarry on the north-west side of the Kosov Hill near Beroun-Jarov (Text-Fig. 1).

The lower part of the Kosov Quarry Section was studied in detail by TUREK (1983, 1990). The whole section was studied by BOUČEK (1941, 1951), HORNÝ (1955c, 1971) and KŘÍŽ (1992).

The top of section no. 767, exposed on the 6th level of the quarry (TUREK, 1990; KŘÍŽ, 1992) is formed by dark calcareous shales with dark micritic limestone concretions which overlay the endostratic breccia (layer no. 14). 55 cm above the endostratic breccia the shells contain first representatives of *T. testis* indicating the base of the *T. testis* Subzone. *Cyrtograptus hamatus* and *M. priodon flemingii* occur together.

The total thickness of this subzone has been estimated in the Kosov Quarry to be 20 m, together with basalt intrusions included up to 30 m (TUREK, 1983). The characteristic pioneer benthic community described by TUREK (1983) occurs 90 to 100 cm above bed no. 14. Most characteristic for this community are nektobenthic cephalopod shells deposited at the bottom and providing the firm substrate for the attachment of epibyssate forms of benthos. In some cases graptolite clusters ("comets") formed by the interception of rhabdosomes on an orthoceracone nautiloid shell sticking obliquely in the bottom sediment were observed. They represent good evidence for the orientation of the shells by bottom current which had a dominant trend from WSW to ENE (TUREK, 1983). Smooth indeterminable cephalopods are the common. Other forms belong to the following genera: *Parakionoceras, Geisonoceras, Rizoceras* and *Peismoceras*. The frequent occurrence of aptychopsids in some layers is interesting.

The epifauna is related to the substratum which in most cases was provided by empty cephalopod shells, algae or living benthic organisms: The brachiopod *Lissatrypa*, crinoids of the group *Flexibilia*, the epibyssate bivalves *Cardiola agna* and *Butovicella migrans*, the gastropod *Platyceras*, the annelid *Spirorbis* and bryozoans. The reclining bivalve *Dualina* and infaunal *Slava* cf. *fibrosa* represent the only fauna related directly to the bottom sediment.

Graptolites as planktic organisms are very abundant and are represented by a characteristic association of *T. testis, C. lundgreni, M. priodon flemingii* (rhabdosomes up to 35 cm long), *M. dubius, M. pseudodubius, P.* aff. *lodenicensis, Monoclimacis flumendosae* and *C. trilleri*. The complete absence of retiolitids (TUREK, 1983) is striking. Besides graptolites carbonized fragments of the nonvascular plants *Prototaxites* and *Pachytheca* of different size occur as representatives of plankton.

The shales of the *T. testis* Subzone are overlain by volcanics which correspond to the uppermost Wenlock and which are exposed on the 5th level of the quarry. They are represented by volcaniclastic agglomerate which is replaced in the central thickest part (up to 40 m according to HORNÝ, 1955a) towards NE by effusive basalts with an amygdaloidal structure, carrying calcitic amygdales. At the base and in the uppermost parts the agglomerate contains large fragments up to several tens of centimetres of the graptolite shales with common *M. priodon flemmingii* indicating the *T. testis* Subzone.

The effusive basalts and volcaniclastics correspond in the Kosov Volcanic Centre to the period from the *M. dubius parvus* Biozone up to the *M. gerhardi/M. vulgaris* Biozone. During the upper Wenlock this part of the Prague Basin shallowed due to the formation of a subsurface volcanic dome caused by many basalt intrusions which produced a cedar-tree laccolith structure (KODYM, 1925). Feeders to the Kosov Volcanic Centre followed the Tobolka Fault. This complex comprises more than 300 m of peperites, glass picrites and granulates.

The volcaniclastics are overlain in the Kosov Quarry by dark shales with thin intercalations of tuffites with calcite and pyrite (HORNÝ, 1955a) in which the graptolites *M. vulgaris* and *M. dubius* s.l. occur indicating the *M. vulgaris* Biozone.

The sequence continues 5–10 m above the base by 10 m thick grey-green tuffites and tuffaceous shales in which the bioclastic content increases continuously (HORNÝ, 1955a). In the upper 30 m of the sequence the graptolites *M. scanicus*, *M. chimaera*, *M. dubius* s.l. and *Bohemograptus bohemicus bohemicus* occur which correspond to the *M. chimaera* Biozone. In the higher parts of the sequence the brachiopods *Leptostrophiella nebulosa* and *Cyrtia bedya*, the trilobite *Balizoma transiens*, and the bivalve *Butovicella migrans* are characteristic too. In the middle part of the tuffaceous sediments HORNÝ (1955a) discovered in several levels endostratic breccias formed of volcaniclastics, tuffite, micritic to biodetrital and shale fragments, commonly rounded. In the breccias occur the corals *Propora conferta*, *"Barrandeolites" bowerbanki*, *Clathrodiction bohemicum*, the trilobite *Hemiarges heteroclytus*, brachiopods and crinoidal detritus. These levels were interpreted by HORNÝ (1955a) as derived from the "Kozel" limestone complex. More probably, these levels are derived from local accumulations on the Kosov Volcanic Centre which correspond to the *M. vulgaris* Biozone.

In the upper part of the sequence (section no. 776 behind the canteen in the old Kosov Quarry (KŘÍŽ, 1992) in the brown calcareous tuffites with several levels of grey bioclastic tuffitic limestone and grey-brown tuffitic shales the graptolite *Monograptus massai* occurs, known from Libya in the horizon just below *M. fritschi linearis* (JAEGER, 1991), together with the brachiopods *Leptostrophiella nebulosa*, *Alaskospira carens*, *Amphistrophiella standinia*, *Striispirifer viator*, *Isorthis manon*, *Spirinella tureki*, *Ancilotoechia tinea*, *Resserella canalis*, *Dalejina* sp., *"Atrypa"* sp.n., *Cyrtia bedya*, *Lissatrypa fumida*, the trilobites *Balizoma transiens*, *Cheirurus* sp., the bivalve *Cardiola* cf. *docens* and the monoplacophorid *Undicornu carens*. This part of the sequence represents high levels of the *M. chimaera* Biozone.

5. Correlation of the Wenlock/Ludlow Boundary in the Prague Basin

The discovery of a complete set of graptolite zones at the Všeradice Section (Text-Figs. 2, 16) enabled the correlation with other sections within all segments of the Silurian Prague Basin and with the contemporary volcanism. The *M. dubius parvus* Biozone with a characteristic brachiopod and trilobite community was also discovered in the Western Segment of the Prague Basin (Koněprusy Section and Borek), the Northern Segment (Lištice Section and Hačka Section), the Pankrác Segment (Pankrác, Braník Section) and in the Central Segment (Konvářka Section).

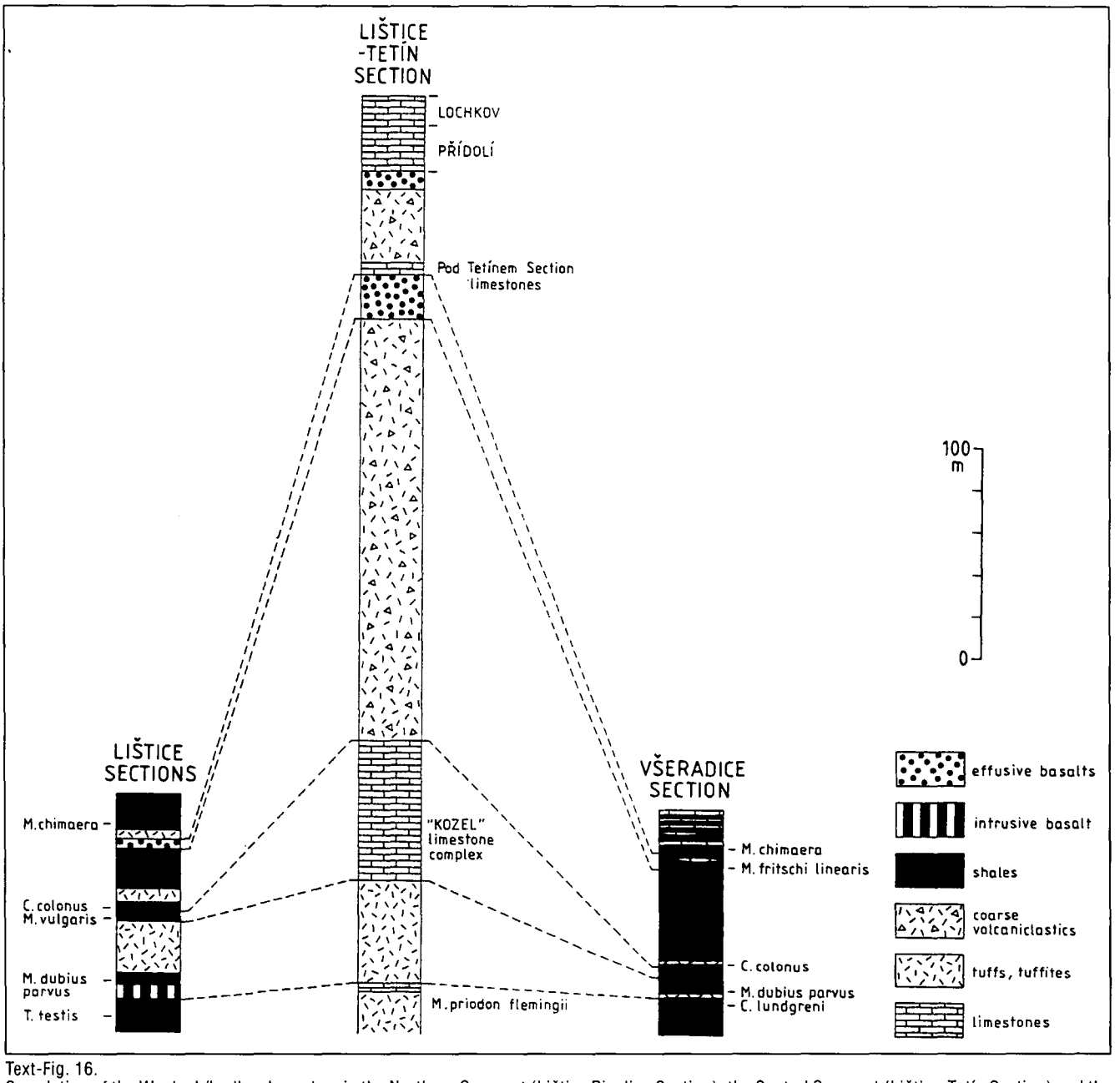
The occurrence of the brachiopod and trilobite *Decoroproetus-Ravozetina* Community in the *M. dubius parvus* Biozone is very important. This community appears abruptly. Some of its representatives are entirely new for the Prague Basin like the trilobite genus *Delops* known from older rocks of the Welsh Borderland. Some of the genera reoccur in the Silurian of the Prague Basin like the brachiopod genus *Ravozetina* which is known from upper Ordovician rocks. Some of the species have ancestors in the underlying *T. testis* Subzone and few of them occur in the *T. testis* Subzone. The community is restricted to the *M. dubius parvus* Biozone and may be characterized by the quite common occurrence of complete trilobites (*Raphiophorus roualti*, *Decoroproetus miser miser*, *Borkopleura gorella*, *Miraspis simara babaricha*, *Rabuloproetus borekensis* a.o.). The facies was influenced by volcanic activity. In the shales fragments of volcanic glass and tuffaceous laminae occur. It is possible that the common occurrence of complete trilobites represents short catastrophic events, possibly involving adverse changes in the chemistry of the environment, similar to the environment of "*Aulacopleura* Shales" in the underlying *T. testis* Subzone. Characteristic for the community is the presence of thallophyt fragments, the hyolithid *"Ortotheca" pulchra* and the plumulitid *"Plumulites" minimus*.

In most of the volcanic centres of the Prague Basin, intensive volcanic activity started in the *M. dubius parvus* Biozone (in the Kosov Volcanic Centre, Svatý Jan Volcanic Centre and Nová Ves Volcanic Centre). In the Kosov Volcanic Centre the volcanic activity terminated below the *M. vulgaris* Biozone, in the Svatý Jan Volcanic Centre volcanic activity was interrupted prior to the *M. vulgaris* Biozone when the "Kozel" Limestone complex was deposited, and continued again in the *C. colonus* Biozone. In the Nová Ves Volcanic Centre the volcanic activity terminated in the *M. vulgaris* Biozone.

The "Kozel" Limestone complex was deposited on the shores of the volcanic accumulation of the Svatý Jan Volcanic Centre. These limestones occur just above the volcanics which overlay the limestones with *M. priodon flemingii* and the brachiopod community characterized by the almost monospecific association of *Buceqia obolina*. Presumably they were deposited in the upper parts of the *C. lundgreni* Biozone. The volcanics correspond most probably to the *M. dubius parvus* Biozone and continue up to the lower portions of the *M. vulgaris* Biozone. Sedimentation of the "Kozel" Limestone complex in the Central Segment started due to accumulation of volcanics and regression in the middle portion of the *M. vulgaris* Biozone (Text-Figs. 12,16).

In the very shallow-water "Kozel" Limestone complex the community is mainly characterized by the presence of corals, stromatoporoids and by leptaenid brachiopods. Only at the base of the complex the high diversity *Hircinisca-Ancillotoechia* Community is developed.

In the Northern Segment the contemporary but deeper water limestones of the *M. vulgaris* Biozone from the Lištice pipeline temporary exposure (Text-Fig. 9,16), the community dominated by *Indaclor sulcicarens* contains also the genus *Ravozetina* which is known only from the older *M. dubius parvus* Biozone. Other brachiopods show either relationships to older Wenlockian communities or to the Coral-Crinoid Community (HAVLÍČEK and ŠTORCH, 1990) known from the lower Ludlow Kopanina Formation in the Kozolupy Smoking Quarry and in the Amerika Quarries.



Text-Fig. 16.
Correlation of the Wenlock/Ludlow boundary in the Northern Segment (Lištice Pipeline Section), the Central Segment (Lištice-Tetín Section) and the Southern Segment (Všeradice Section) of the Prague Basin.

With the *M. vulgaris* Biozone may be also correlated the lowermost part of the sequence exposed in the trench close to Smoking Quarry near Kozolupy. The community here differs from all other communities known from this level but contains forms characteristic for the lower part of the "Kozel" limestone complex like the brachiopods *Aratoechia arabella, Atrypina paulula, Pseudoprotathyris ephemera, Cyrtia maior maior, Janius nobilis, Mendacella venustula* and *Amphistrophia harperi*. The rare brachiopod *Niorhynx niobe* represents a typical Wenlockian species and the occurrence of *Indaclor sellarius* indicates that the community is closely related to the communities with dominant *Indaclor* characteristic for the boundary rocks between the *M. vulgaris* Biozone and *C. colonus* Biozone. The community is also closely related to the community from the Lištice locality 579 – pipeline exposure – with concern to the presence of the trilobites *Interproetus soncobrinus, Conoparia clarimonda* and *Cheirurus* sp.

During the *C. colonus* Biozone the maximum of volcanic activity in the Svatý Jan Volcanic Centre was reached. It was interrupted in the lower Ludlow, most probably in the *M. chimaera* Biozone, for a shorter period to continue again in the middle Ludlow. In the slightly deeper environment in the Northern Segment (Vysoký Újezd) the sedimentation of carbonates with a brachiopod-trilobite community characterized by dominant *Indaclor sulcicarens* continued from the *M. vulgaris* to the *C. colonus* Biozone.

It is possible to characterize the benthic communities development in the Prague Basin during JAEGER's "Big Crisis" as an abrupt change. The deeper water *Cardiola agna* Community developed in the uppermost *C. lundgreni* Biozone but disappeared before the sedimentation of the *M. dubius parvus* Biozone and was not replaced by another bivalve-dominated community.

Rich relatively shallow water brachiopod-trilobite communities of the upper *C. lundgreni* Biozone were replaced by the *Decoroproetus-Ravozetina* Community which shows a different structure and an adaptation to deeper water environment.

Concerning the development of benthic communities at the boundary between the *M. vulgaris* Biozone and the *C. colonus* Biozone it may be stated that relatively deeper water carbonate sediments below and above the boundary contain the same bivalves dominated by the *Cardiola gibbosa* Community and in the relatively shallow water sediments the same brachiopod-dominated community characterized by the dominant occurrence of *Indaclor sulcicarens*. The situation with the trilobites is similar. Communities below and above the boundary are characterized by the dominance of *Interproetus* and *Eophacops* in relatively shallow water sediments.

The crisis in the graptolite evolution described by JAEGER was also contemporary with the distinct change of the chitinozoan association. According to DUFKA (MS) the almost monospecific assemblage characterized in the *T. testis* Subzone by *Conochitina tuba* was abruptly replaced at the base of the *M. dubius parvus* Biozone by an assemblage with ?*Eisenackitina* sp. and *Eisenackitina* cf. *intermedia*.

6. International Correlation

The development of the graptolite biozonation at the Wenlock/Ludlow boundary in the shale facies is very similar to the scheme described by JAEGER (1991) from Thuringia, South Spain, Gotland and Latvia. The benthic *Decoroproetus-Ravozetina* Community is till now characteristic only for the Prague Basin.

It is interesting that the "Kozel" limestone complex with a thickness of 14–63 m shows similar features with the Much Wenlock Limestone in the Welsh Borderland. Both limestone formations formed in shallow water and both may directly or indirectly correspond to the *M. vulgaris* (*M. ludensis*) Biozone.

7. Significance of Stratigraphically Important Animal and Plant Groups in Defining the Wenlock/Ludlow Boundary in the Prague Basin

7.1. Graptolithina

(By JIŘÍ KŘÍŽ)

H. JAEGER had been visiting Bohemia almost every year since 1958 to systematically collect graptolites in the Silurian and Devonian of the Prague Basin. During his last visit in August 1991 we collected graptolites at the locality Všeradice (no. 717). Later, during the end of the year 1991

Table 1.
Distribution of benthic communities at the Wenlock/Ludlow boundary interval in the Prague Basin.

GRAPTOLITE BIOZONES		BIVALVIA COMMUNITIES	TRILOBITE ASSEMBLAGES	BRACHIOPOD COMMUNITIES
M.fritschi linearis		Cardiola docens	Encrinuraspis-Eophacops	Smooth Atrypid Leptostrophiella nebulosa
M.chimaera (M.scanicus)		Cardiola donigala	Sphaeroxochus-Proetus	Atrypoidea renitens
C.colonus (N.nilssoni)		Cardiola gibbosa	Interproetus-Eophacops	Indaclor sulcicarens
M.vulgaris - M.gerhardi		Cardiola gibbosa	Richterarges-Eophacops Richterarges-Eophacops	Indaclor sulcicarens Septatrypa lissodermis-Cyrtia maior Coral-Leptaenid Hircinisca-Ancylotoechia
M.deubeli				
M.praedeubeli				
M.dubius frequens - G.nassa				
M.dubius parvus			Raphiophorus-Delops	Ravozetina-Bracteoleptaena
C.lundgreni	T.testis	Cardiola agna	Aulacopleura koninckii Bumastus-Sphaerexochus-Cheirurus	Buceqia obolina Plicocyrtia
	C.radians		Bumastus-Sphaerexochus-Cheirurus	Strophoprion-Eoplectodonta

more graptolites were found by J. KŘÍŽ at the sections Koněprusy (no. 781), Hačka (no. 758), Vysoký Újezd (no. 567), Lištice Pipeline Section (no. 579) and Lištice Section (nos. 759 and 770) and identified by H. JAEGER during the visit of J. KŘÍŽ and P. DUFKA in Berlin in March, 1992.

The results of H. JAEGER's research were included into the sections figured and described in this paper since he was unable to complete his whole life work.

When summarized, it was discovered that at the end of the *T. testis* Subzone (*C. lundgreni* Biozone) the Prague Basin was influenced by the same event which was responsible for the "big crisis" (JAEGER, 1991) in other regions.

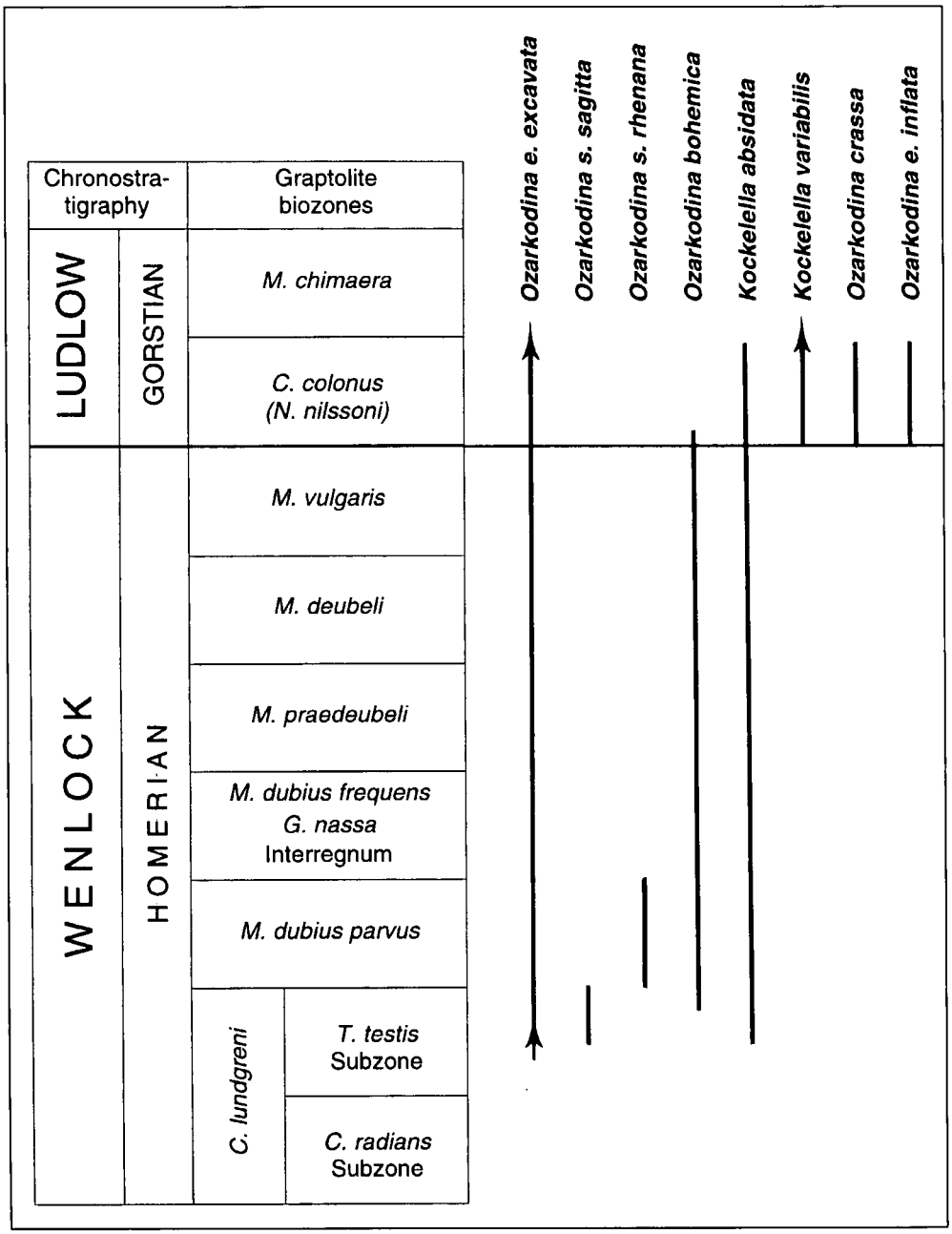
It was demonstrated at the only complete section in the shale facies which was exposed as the Všeradice Section (KŘÍŽ, 1992) where all upper Wenlock zones above the *T. testis* Subzone up to the *C. colonus* Biozone were discovered by H. JAEGER in 1991.

7.2. Conodonta

(H.P. SCHÖNLAUB; Plate 1)

In terms of the currently used Silurian conodont zonation, the boundary between the lower and upper Silurian, i.e. the boundary between the Wenlock and Ludlow Series has been poorly defined (R.J. ALDRIDGE, 1975, R.J. ALDRIDGE & H.P. SCHÖNLAUB, 1989). This applies to the stratotype at Pitch Coppice quarry near Ludlow (A. MARTINSSON et al., 1981) as well as to other areas of the world for which a conodont-based zonation for the Silurian has been established in recent years (for summary see B.J. COOPER, 1980; R.J. ALDRIDGE, 1985).

Since the study of O.H. WALLISER (1964), however, it became clear that the Bohemian sections of the shelly facies may provide additional data as some shale interbeds also contain graptolites which serve as leading fossils for the definition of the Wenlock/Ludlow boundary. In addition, a whole set of new records of graptolites from strata assigned to the upper Wenlock has been found recently which supply useful information to tie conodonts into the graptolite-based framework of this particular timespan.



Text-Fig. 17.
Range-chart of conodonts across the Wenlock/Ludlow boundary.

This report summarizes the available conodont data from 36 samples of several sections listed and described in the foregoing text. They span the interval from the upper range of *Testograptus testis* to the *Colonograptus colonus* Biozones. The corresponding range-chart is shown in Text-Fig. 17.

Yet, limestone samples from only 8 out of 20 sections produced conodonts, i.e. Braník, Butovice, Arethusina Gorge, Lištice 770, Lištice 579, Lištice 759, Vysoky Újezd and U Drdů. The remaining sections were either not sampled or were as yet not productive.

The long ranging taxon *Ozarkodina e. excavata* occurs in strata assigned to the *T. testis* Biozone (Lištice section 759 in association with *O. s. sagitta*), the interval between the *M. dubius parvus* and the *M. vulgaris* Biozones (Braník 764 section), the interval between the *M. vulgaris* and the *C. colonus* Biozones (Lištice Pipeline section 579) and in the *C. colonus* Biozone (Butovice 584 section, Vysoký Újezd section 567 and outcrop between Lištice section nos. 770 and 759). In addi-

tion, it co-occurs with *O. bohemica* in the Kozel Lst. of the U Drdů section.

Ozarkodina s. sagitta has yet only been recovered from the Lištice section 759 within the range of the index graptolite species *T. testis* and from the Arethusina Gorge section 687 in strata corresponding to the upper *T. testis* Biozone. At the latter locality the name-bearer of the *sagitta* conodont Zone is associated with "early" representatives of *Ozarkodina bohemica*.

Ozarkodina occurs in a short section below the Lištice Pipeline section 579 in strata assigned to the *M. dubius parvus* Biozone (for the accompanying fauna see chapter 4.8.).

Ozarkodina bohemica has its first appearance in the upper part of the *T. testis* Biozone (Arethusina Gorge section 687). It ranges through the *M. vulgaris* Biozone (Braník section 764, Lištice Pipeline section 579) to the basal part of the *C. colonus* Biozone (Butovice section 584). This latter occurrence confirms the data of WALLISER, 1964 who named the same locality "Jinonice".

O. bohemica is the most characteristic conodont species of the Kozel Lst. at the U Drdů section 760. They represent intermediate "morphotypes" between early occurrences of the Arethusina Gorge section (*T. testis* Zone) and those from the Braník and Butovice sections of the *M. vulgaris* and *C. colonus* Biozones, respectively. Hence, for the Kozel Lst. an age within the late Wenlock is concluded.

Kockelella absidata ranges from the *T. testis* Biozone (Lištice section 759) to the lower portion of the *C. colonus* Biozone (Vysoký Újezd section 567). A record from an interval in between was provided in the Lištice Pipeline section 579 within the upper *M. vulgaris* Biozone.

Kockelella variabilis has yet only been found in strata containing index graptolites of the basal Ludlow, i.e. at Butovice section 584 and Vysoký Újezd section 567. In addition, the latter section yielded the only characteristic representatives of *O. crassa*.

In sample 774/2 from an outcrop between the Lištice sections 770 and 759 *Ozarkodina e. inflata* is the dominating conodont taxon. Based on associated graptolites for this horizon an age within the *C. colonus* Biozone, i.e. basal Ludlow can be concluded.

The available conodont fauna suggests a low diversity. It is dominated by different species of *Ozarkodina* and *Kockelella* which represent long and short ranging taxa, respectively. From the time relationship and morphological similarities it is most obvious that *Ozarkodina s. rhenana* evolved from the nominate subspecies in the *M. dubius parvus* Biozone. Whether this subspecies is also the ancestor of *Ozarkodina bohemica* seems quite possible. Such a relationship can be found in a sample from the upper *T. testis* Zone of the Arethusina Gorge section in which both taxa co-occur. We illustrate those specimens on Plate 1.

The interval from the base of the following *"dubius-nassa*-Interregnum" to the base of the *C. colonus* Zone is characterized by the main occurrence of *Ozarkodina bohemica*. Most apparently, the phylogenetic development of this species reflects three distinct stages named herein morphotype 1 to 3:

- **Morphotype 1**
  is the oldest representative occurring in the upper part of the *T. testis* Zone in conjunction with *O. s. sagitta*. In lateral view the Pa element strongly resembles *O. s. sagitta* showing a blade steadily decreasing in height. The main difference is the outline of the basal cavity which occupies the posterior part of the blade. In oral view it is significantly expanded in comparison with the arrow-like shape of that of *O. s. sagitta* and *O. s. rhenana*.
- **Morphotype 2**
  occurs in sample 712/34 in the uppermost *M. vulgaris* Zone of the Lištice Pipeline section 579. In oral view this representative of *O. bohemica* is characterized by a broadly expanded flat and subcircular basal cavity the surface of which is ornamented by short oblique ridges of fused denticles. The anterior part of the straight blade bears the highest denticles which become fused about midlength and above the basal cavity to form a ridge of more decreased height than at the anterior portion.
- **Morphotype 3**
  co-occurs with the former representative but extends to strata assigned to the basal *C. colonus* Biozone of the lower Ludlow Series. The Pa element suggests a very close relationship with *O. bohemica* subsp.nov. illustrated and shortly described by R.J. ALDRIDGE, 1985. Also, it may be related to specimens named *Spathognathodus s. bohemicus* and *Hindeodella snajdri* described by L.E. FAHRAEUS, 1969 and L. JEPPSSON, 1983 from the late Wenlock Halla and Mulde Beds of Gotland, respectively. Typical representatives of *O. snajdri*, however, are distinguished from *O. bohemica* by a blade of varying height and a more broadly expanded and more or less asymmetrical cavity. In the central Appalachians C.T. HELFRICH (1975) used similar although not identical specimens to define a special conodont zone bridging the Wenlock/Ludlow boundary.

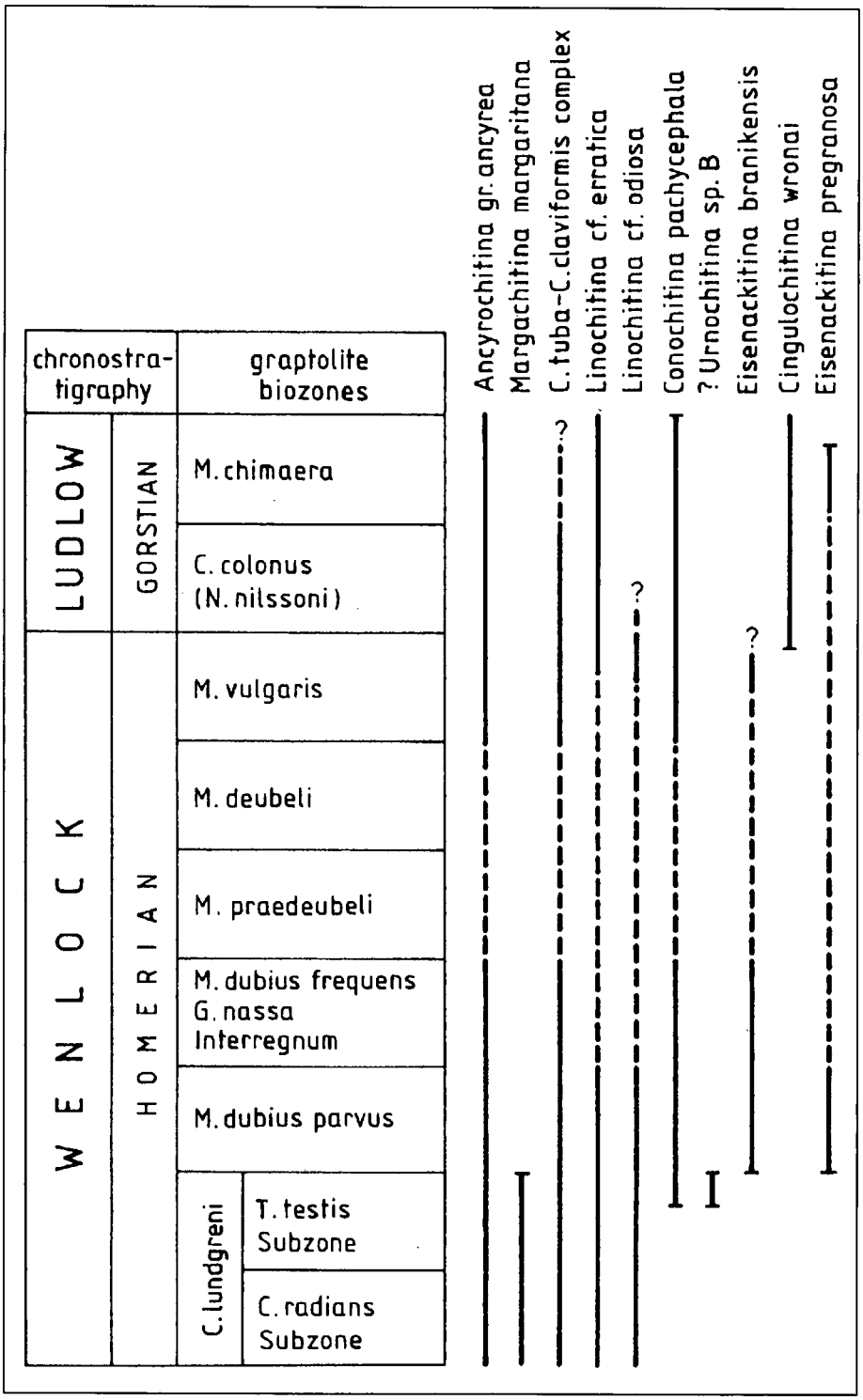
As far as the degree of fusion and height of the blade is concerned Morphotype 3 shows a great variation. At hand are those specimens with an evenly high blade at the anterior and middle part of the blade which decreases fairly abruptly at the posterior termination. Three to five denticles above the flat basal cavity may be fused. The subcircular and rarely also heart-shaped cavity may be symmetrical or asymmetrical. Generally, the flat cavity is flaring from the midpoint and extends to or almost to the posterior end of the blade (for comparison see Plate 1).

The specimen illustrated by O.H. WALLISER (1964) on Pl. 18, Figs. 25 and cited as *Spathognathodus* cf. *sagitta* suggests a close similarity with our Morphotype 3. At Cellon section it is derived from sample bed $15B_1$, i.e. the bed immediately below the appearance of the zonal index *Ozarkodina crassa*. In the Vysoký Újezd section of the Barrandian region this taxon together with *Kockelella variabilis* and *O. e. inflata* first occurs in strata corresponding to the lowermost Ludlow Series of the stratotype. This well comparable order of appearance in both the Barrandian and the Carnic Alps seems reliable and thus suggests contemporaneity. It may help to define a conodont-based Wenlock/Ludlow boundary as shown on Text-Fig. 17 of our report. Consequently, we conclude that the Series boundary at Cellon section must be drawn at the shale interbed between sample nos. 15A and $15B_2$.

7.3. Chitinozoa

(P. DUFKA; Plates 2–3)

A number of recent studies emphasize the importance of chitinozoans for the Silurian biostratigraphy of the Prague Basin. Upper Silurian chitinozoans were studied in the type sections of the Silurian/Devonian boundary (PARIS et al., 1981) and of the Přídolí Series (KŘÍŽ et al., 1986). Subsequently, several biostratigraphic studies on



Text-Fig. 18.
Chitinozoa ranges and graptolite biozonation at the Wenlock/Ludlow boundary in the Prague Basin.

the lower Silurian chitinozoans of graptolite shale sequences were carried out (DUFKA, 1992; DUFKA, 1993a; DUFKA & FATKA, 1993).

The present study of the Wenlock/Ludlow boundary beds is based on samples from 15 sections within the upper Wenlock (Motol Formation) and lower Ludlow (Kopanina Formation) strata (*T. testis* to *M. chimaera* Biozones). From the total number of 190 processed samples, 63 samples from 10 sections yielded determinable chitinozoans. Unfortunately, chitinozoans are almost absent within the Všeradice Section (no. 717) which is nowadays the only accessible locality with a complete set of graptolite biozones around the Wenlock/Ludlow boundary in the Prague Basin.

Ten chitinozoan taxa have been determined in the studied interval (Fig. 18). Such a low chitinozoan diversity is not exceptional for the late Homerian and lower Gorstian sequences, as it was previously documented in Estonia (NESTOR, 1990), Gotland (Klintenberg Beds – LAUFELD, 1974), southern Sweden (LAUFELD et al., 1975) and England (DORNING, 1981).

The chitinozoan distribution through the basin, as well as their abundance and diversity within the individual sections, seem to be controlled by a particular facial development in each segment of the basin. In the shallow water volcano-carbonate facies surrounding the Svatý Jan Volcanic Centre of the Central Segment, the chitinozoans are rare (e.g. section no. 759) or absent in the biodetritic limestone and the tuffitic shales of the *T. testis* Biozone. They are also missing in all samples of tuffitic limestone and calcareous tuffites of the "Kozel" facies (*M. dubius parvus* to *M. vulgaris* Biozones), characterized by the dominance of the sporomorphs of land plants (DUFKA, 1993b). In the Nová Ves Volcanic Centre (section no. 687; *T. testis* to *C. colonus* Biozones) of the Central Segment and in the eastern part of the Central Segment (section no. 764; *M. dubius parvus* to *?M. vulgaris* Biozones), well-preserved but not abundant chitinozoans (< 5 specimens per gram of rock) were recovered from the lenses of micritic limestone enclosed in tuffitic shales.

In adjacent segments of the basin with calcareous or tuffitic shale facies, the occurrence of chitinozoans varies. Chitinozoans have not been recorded in the "*Aulacopleura* Shales" (*C. lundgreni* Biozone) on the Spičatý Hill near Loděnice and in the tuffitic shales of *M. dubius parvus* Biozone south of Hačka Hill near Loděnice (section no. 758). In the vicinity of Lištice Village (section no. 770) very rare chitinozoans (< 1 specimen per gram of rock) were recorded from the micritic limestone of the *M. dubius parvus* Biozone. At Všeradice Section (no. 717), only one sample of micritic limestone from the base of the *C. colonus* Biozone yielded several poorly-preserved specimens of chitinozoans. By contrast, abundant chitinozoans (e.g. > 800 specimens per gram of rock in sample 10 in section no. 781) were found in shales of the *M. dubius parvus* Biozone and the *C. nassa-M. dubius frequens* Interregnum near

Koněprusy (section 781), similarly as in the tuffitic shales and limestone of *M. vulgaris* Biozone near Lištice Village (section no. 597).

The chitinozoan absence in some shale sequences is questionable. Decrease of any insoluble organic residue in shales of the *C. lundgreni* to *C. colonus* Biozones in Všeradice Section suggests that the rocks are barren of chitinozoans due to their recent or fossil alteration.

7.3.1. Biostratigraphy

Seven chitinozoan taxa have been determined from the upper part of the *T. testis* Biozone (Text-Fig. 18). Five of them, *Ancyrochitina* gr. *ancyrea* (EISENACK), *Margachitina margaritana* (EISENACK), *Conochitina tuba* EISENACK, *Linochitina* cf. *erratica* (EISENACK) and *Linochitina* cf. *odiosa* LAUFELD pass in the Prague Basin from the Sheinwoodian to the Homerian (DUFKA, 1993). *Conochitina pachycephala* EISENACK occurs for the first time in the *T. testis* Biozone and ?*Urnochitina* sp. B is restricted to the upper part of this biozone.

The boundary between the *C. lundgreni* and the *M. dubius parvus* Biozones is characterized by a distinct change in the chitinozoan assemblages (Text-Fig. 18). This change corresponds to an extensive crisis in the graptolite evolution described by JAEGER (e.g., 1991). ?*Urnochitina* sp. B and *Margachitina margaritana* disappears at the top of the *T. testis* Biozone. *Eisenackitina branikensis* sp. nov. and *Eisenackitina pregranosa* sp.nov. appear in the *M. dubius parvus* Biozone. E. *branikensis* coincides in the first occurrence with the graptolite *M. dubius parvus* and ranges up to the *G. nassa-M. dubius frequens* Interregnum. *E. pregranosa* has a longer stratigraphic range as compared with *E. branikensis*; however, it was only determined as a rare form in several samples from the *M. dubius parvus* Biozone (section no. 770) and then from the *M. chimaera* Biozone (section no. 687).

No new chitinozoan forms have been recorded in the *G. nassa* and *M. dubius frequens* Interregnum. Similarly as in the underlying *M. dubius parvus* Biozone, *Eisenackitina branikensis* and *Conochitina pachycephala* are of major biostratigraphic importance. *Linochitina* cf. *odiosa* and *Linochitina* cf. *erratica* are missing in samples from the *G. nassa* and *M. dubius frequens* Interregnum.

The succeeding upper Homerian graptolite biozones (*M. praedeubeli*, *M. deubeli* and *M. vulgaris*) are recently accessible only at the Všeradice Section (no. 717), where chitinozoans are absent in this interval.

Cingulochitina wronai PARIS & KŘÍŽ has been recorded for the first time in the upper part of the *M. vulgaris* Biozone (section 597). In the younger strata, *C. wronai* was recorded from the *M. chimaera* Biozone and from the Ludlow/Přídolí boundary beds, where it was originally described (PARIS & KŘÍŽ, 1984). Besides the Prague Basin, it was reported from the *M. chimaera* Biozone of the lower Ludlow in the Palencia Province, Spain (SCHWEINEBERG, 1987).

Chitinozoans are not significant for the definition of the Wenlock/Ludlow boundary (between *M. vulgaris* and *C. colonus* Biozones) in the Prague Basin. No change in the chitinozoan species spectrum has been recognized within the *C. colonus* Biozone and probably all species known from the upper Homerian pass to the lower Gorstian (Text-Fig. 18).

The dominant chitinozoans recorded from the lower Gorstian strata are long-ranging taxa like the *A. ancyrea* group and the *C. tuba-C. claviformis* complex (variable forms with affinities to *C. tuba*, *C. elegans* and *C. claviformis*).

7.3.2. Description of New Species

Genus: *Eisenackitina* JANSONIUS, 1964

Type species: *Eisenackitina* castor JANSONIUS, 1964

Eisenackitina branikensis sp.nov.

(Pl. 3, Figs. 6–10)

1992? *Eisenackitina* sp.– KŘÍŽ, p. 16, p. 3, Fig. 4.
1992 *Eisenackitina* cf. intermedia; KŘÍŽ, p. 16, Pl. 3, Fig. 5.

Holotype: Pl. 3, Fig. 10, sample 781–7–9, slide GSP–296, deposited in author's collection at the Czech Geological Survey, Prague.

Type locality and type horizon: Koněprusy, section 781, Prague Basin (Bohemia); *M. dubius parvus* Biozone, Homerian, Wenlock.

Material: 480 partially flattened specimens from the section 781 and 135 three-dimensional specimens from the section 764. All specimens deposited in the authors collection at the Czech Geological Survey, Prague.

Diagnosis: *Eisenackitina* species with a club-shaped chamber terminated by distinct collarette. The basal margin is rounded or inconspicuous and the base is convex, provided by broad, protruded mucron. The ornamentation consists of tubercles, short spines and coalescent rugae. The latter are developed especially around the basal margin.

Dimensions: Based on 32 three-dimensional specimens and 32 partially flattened specimens. Flattening corrected for Dc and Dp values by multiplying with a 0.8 coefficient. Measurements in μm.

	L	Dp	Dc
Holotype	224	98	58
Mean	228	105	59
Range	177–296	94–124	52–68

Comparison: *Conochitina lagena* EISENACK has a different trend of the L/Dp variations (see EISENACK, 1968, Fig. 9) and, according to the original diagnosis, "fine granulate ornamentation". *Conochitina gutta* LAUFELD is ornamented by low ruggae, arranged more or less in a polygonal pattern (LAUFELD, 1974, Fig. 25:E) and dispersed over the whole vesicle.

Stratigraphic distribution: *M. dubius parvus* Biozone to *M. dubius frequens-G. nassa* Interregnum (sections no. 781 and no. 764).

Eisenackitina pregranosa sp.nov.

(Pl. 3, Figs. 1–5)

? *Eisenackitina lagenomorpha* (EISENACK) – NESTOR, Pl. 15, Fig. 12.

Holotype: Pl. 3, Fig. 2. Sample 687-8, slide GSP-135, deposited in author's collection in the Czech Geological Survey, Prague.

Type locality and type horizon: Řeporyje, section no. 687 (Mušlovka), Prague Basin (Bohemia); *M. chimaera* Biozone, Gorstian, Ludlow.

Material: 50 three-dimensional specimens from the sections no. 770 and no. 687. All specimens are deposited in the authors collection at the Czech Geological Survey, Prague.

Diagnosis: *Eisenackitina* species with barrel-shaped chamber, short collarette and inconspicuous basal margin. The central part of the base is slightly concave, provided with a discrete anteapertural mark consisting of the central scar and the central pit. The vesicle ornamentation is composed of distinct granas and cones, 1.5–2 μm in high and 2–3 μm in width.

Dimensions: Based on 25 three-dimensional specimens. Measurements in μm.

	L	Dp	Dc
Holotype	156	104	68
Mean	154	105	65
Range	140–182	94–120	62–73

Comparison: *Eisenackitina pregranosa* has the identical sculpture and the character of the anteapertural mark as *Eisenackitina granosa* (LAUFELD) which is a typical upper Ludlow taxon. However, both species distinctly differ in the vesicle size and shape. The dimensions of the originally described population of *E. granosa* are following (LAUFELD, 1974, p. 61): "length 95–120 μm, greatest width 48–55 μm, width of aperture 33–42 μm".

Stratigraphic distribution: *M. dubius parvus* Biozone (section no. 770), probably *M. vulgaris* Biozone (section no. 759), *M. chimaera* Biozone (section 687).

7.4. Sporomorphs

(PAVEL DUFKA)

Highly-diversified assemblages of dispersed trilete miospores and cryptospores were recovered from the upper Homerian tuffitic shales and limestones in the region of the Svatý Jan Volcanic Centre. Local occurrence of abundant sporomorphs as well as their dominance over the marine microphytoplankton, documented in the section no. 760 (Lištice near Beroun), indicate the vegetation of higher land plants on the emerged Svatý Jan Volcanic elevation during the uppermost Wenlock.

Twenty-nine sporomorph forms were reported by DUFKA (DUFKA, 1993b). Among these forms are included several index species typical for the *Artemopyra brevicosta-Hispanaediscus verrucatus* Sporomorph Biozone (RICHARDSON & MCGREGOR, 1986; BURGESS & RICHARDSON, 1991): *Artemopyra brevicosta* BURGESS & RICHARDSON, *Hispanaediscus verrucatus* (CRAMER), *Emphanisporites protophanus* RICHARDSON & IOANNIDES, *Synorisporites libycus* RICHARDSON & IOANNIDES and *Synorisporites* cf. *verrucatus* RICHARDSON & LISTER.

The close resemblance between the sporomorph assemblages of the Prague Basin and coeval assemblages from the Great Britain Wenlock Limestone (e.g. BURGESS & RICHARDSON, 1991), Libya (RICHARDSON & IOANNIDES, 1973), Spain (RODRIGUEZ, 1978) and North America (STROTHER & TRAVERSE, 1979; MCGREGOR & NARBONNE, 1978) suggests the parallel early evolution of higher land plants in these regions.

8. Conclusions

It may be concluded that in the Prague Basin the crisis in the graptolite evolution at the boundary between the *C. lungreni* Biozone and the *M. dubius parvus* Biozone (JAEGER, 1991) was accompanied by a distinct change in the chitinozoan association development and by the appearance of new benthic forms in the distinct *Decoroproetus-Ravozetina* Community.

The tectonic development of the Prague Basin during the *M. dubius parvus* Biozone, *M. dubius frequens-G. nassa* Interzone, *M. praedeubeli* Biozone and *M. deubeli* Biozone was accompanied by a prominent volcanic activity in all volcanic centers along the deep synsedimentary faults which represented the margins of the Central Segment where the largest subsidence during the Silurian was recorded (Text-Fig. 16). Due to the volcanic activity, the Svatý Jan Volcano elevation developed and was emerged above sea level (KŘÍŽ, 1991). The finds of spores (DUFKA, 1993a) in its marginal shallow water carbonates of the "Kozel" Limestone complex document the presence of a diversified association of land plants on the island.

It may be presumed that all described changes in the Prague Basin which were contemporary with JAEGER's "Big Crisis" (JAEGER, 1991) are related to a global change in water circulation (currents transported new benthic forms from other regions into the basin), and to synsedimentary tectonic changes at least in this part of Gondwana which were responsible in the Prague Basin for volcanic activity at the base of *M. dubius parvus* Biozone in all volcanic centres.

The shallowing of the Prague Basin during the *M. vulgaris* Biozone in the Northern Segment and in the Central Segment may be related to the global regression the effect of which was locally increased by earlier accumulation of volcanics during the *M. dubius parvus* Biozone and the *M. deubeli* Biozone interval.

JAEGER's "Big Crisis" in graptolite evolution (JAEGER, 1991) represents a distinct bioevent which may be directly related to global plate tectonic regimes.

Plate 1

Figs. 1,3,4: ***Ozarkodina bohemica* (WALLISER), Morphotype 1.**
Prostřední Mill Section No. 713, sample no. 10; *T. testis* Zone.
Figs. 1,3: Lateral and oral views.
Fig. 4: Oral view.

Figs. 2,5: ***Ozarkodina s. sagitta – Ozarkodina bohemica* transitional type.**
Arethusina Gorge section No. 687; *T. testis* Zone.

Fig. 6: ***Ozarkodina sagitta sagitta* (WALLISER).**
Arethusina Gorge section No. 687; *T. testis* Zone.

Fig. 7: ***Ozarkodina sagitta rhenana* (WALLISER).**
Lištice section No. 770; *M. dubius parvus* Zone.

Fig. 8: ***Ozarkodina excavata inflata* (WALLISER).**
Lištice, outcrop between sections Nos. 770 and 759; *C. colonus* Zone.

Fig. 9: ***Ozarkodina bohemica* (WALLISER), Morphotype 2.**
Lištice Pipeline section No. 579 (sample 712/34); *M. vulgaris* Zone.

Fig. 10: ***Ozarkodina bohemica* (WALLISER), Morphotype 3.**
Fig. 10: Oral view from Butovice section No. 584/10; *C. colonus* Zone.
Fig. 11: Oral view from Braník section No. 764; *M. vulgaris* Zone.
Fig. 12: Oral view from Lištice Pipeline section No. 579, sample No. 21; *M. vulgaris* Zone.
Fig. 13: Lateral view from Butovice section No. 584/10; *C. colonus* Zone.
Fig. 14: Lateral view from Braník section No. 764; *M. vulgaris* Zone.

Fig. 15: ***Kockelella absidiata* (LANE).**
Butovice section No. 584/10; *C. colonus* Zone.

Fig. 16: ***Kockelella variabilis* (BRANSON & MEHL).**
Lateral view from Lištice Pipeline section No. 579, sample No. 34; *M. vulgaris* Zone.

Figs. 17–18: ***Ozarkodina crassa* (WALLISER).**
Fig. 17: Lateral view from Vysoký Újezd section No. 567, sample No. 10 (uppermost 30 cm); *C. colonus* Zone.
Fig. 18: Lateral view from Butovice section No. 584/10; *C. colonus* Zone.

All photos by Dr. H. PRIEWALDER, Geologische Bundesanstalt, Wien.

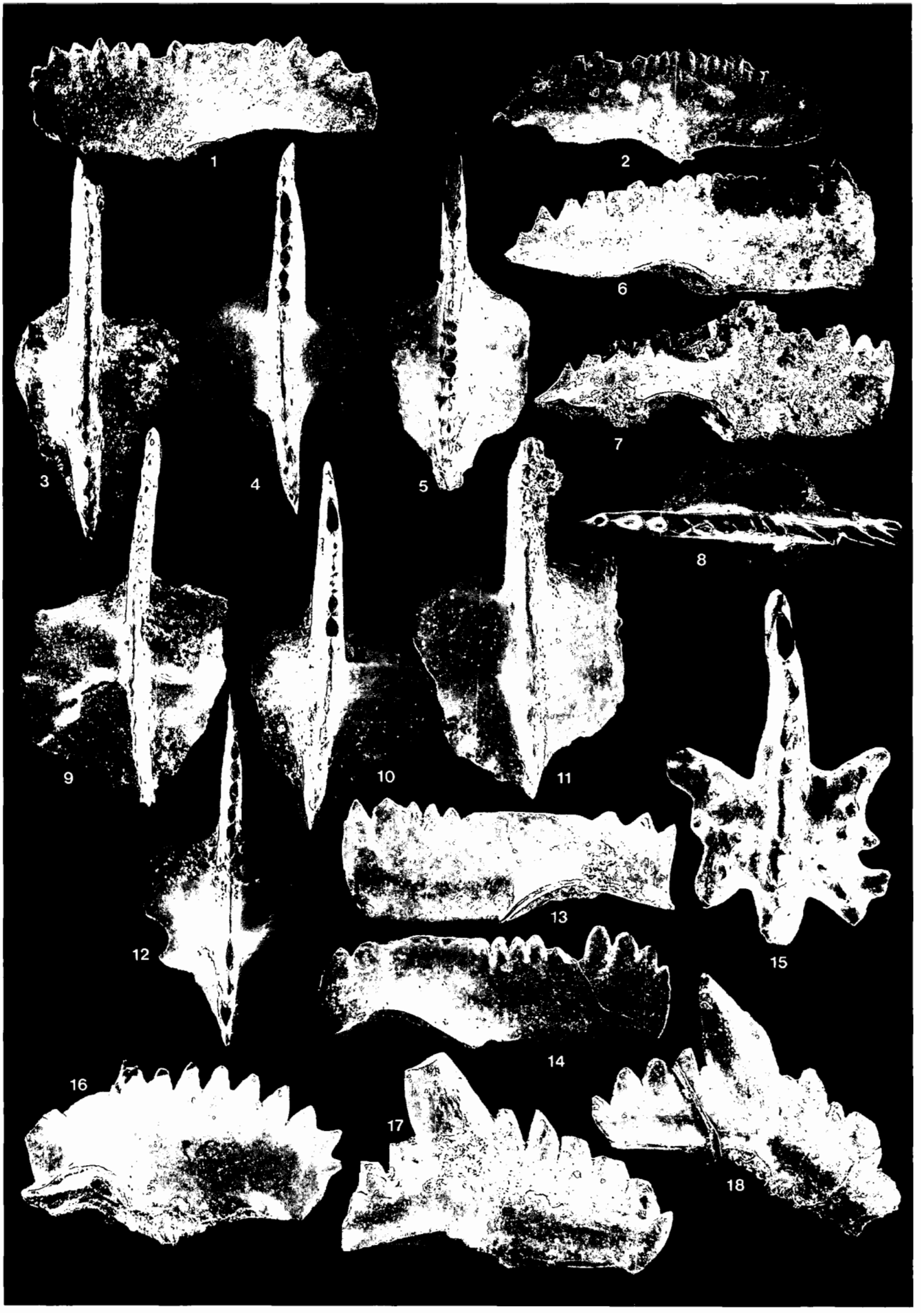


Plate 2

Figs. 1– 2: ***Cingulochitina wronai*** **PARIS & KŘÍŽ.**
Section no. 597, sample 36, *M. vulgaris* Biozone, GSP 277.
Fig. 1: ×400.
Fig. 2: Detail of the anteapertural end showing the rim of carina; ×800.

Figs. 3– 4: ***Cingulochitina wronai*** **PARIS & KŘÍŽZ.**
Section no. 597, sample 8, *M. vulgaris* Biozone, GSP 256.
Fig. 3: Flattened specimen adhered to the basal part of the proceeding vesicle; ×275.
Fig. 4: Detail of carina; ×850.

Fig. 5: ***Linochitina*** **cf. *erratica*** **(EISENACK).**
Section no. 781, bed 1, sample 2, *T. testis* Biozone, GSP 287; ×300.

Fig. 6: ***Linochitina*** **cf. *odiosa*** **LAUFELD.**
Section no. 781, bed 1, sample 2, *T. testis* Biozone, GSP 287; ×300.

Figs. 7– 8: **?*Urnochitina* sp. B.**
Section no. 584, *T. testis* Biozone.
Fig. 7: Bed 2, sample 1, GSP-110; ×250.
Fig. 8: Bed 2, sample 3, GSP-113; ×230.

Fig. 9: ***Conochitina*** **cf. *tuba*** **EISENACK.**
Section no. 597, sample 60, *M. vulgaris* Biozone, GSP 277; ×300.

Fig. 10: ***Margachitina margaritana*** **EISENACK.**
Section no. 781, bed 1, sample 1, *T. testis* Biozone, GSP 287; ×350.

Figs. 11–12: ***Conochitina pachycephala*** **EISENACK.**
Section no. 597, sample 36, *M. vulgaris* Biozone.
Fig. 11: GSP 277; ×250.
Fig. 12: GSP 277; ×250.

Fig. 13: ***Conochitina*** **cf. *pachycephala*** **EISENACK.**
Section no. 764, bed 6, sample 12, *M. dubius frequens* – G. *nassa* Interregnum, GSP-94; ×180.

Fig. 14: ***Conochitina*** **cf. *pachycephala*** **EISENACK.**
Section no. 764, bed 6, sample 11, *M. dubius frequens* – *G. nassa* Interregnum, GSP-90; ×150.

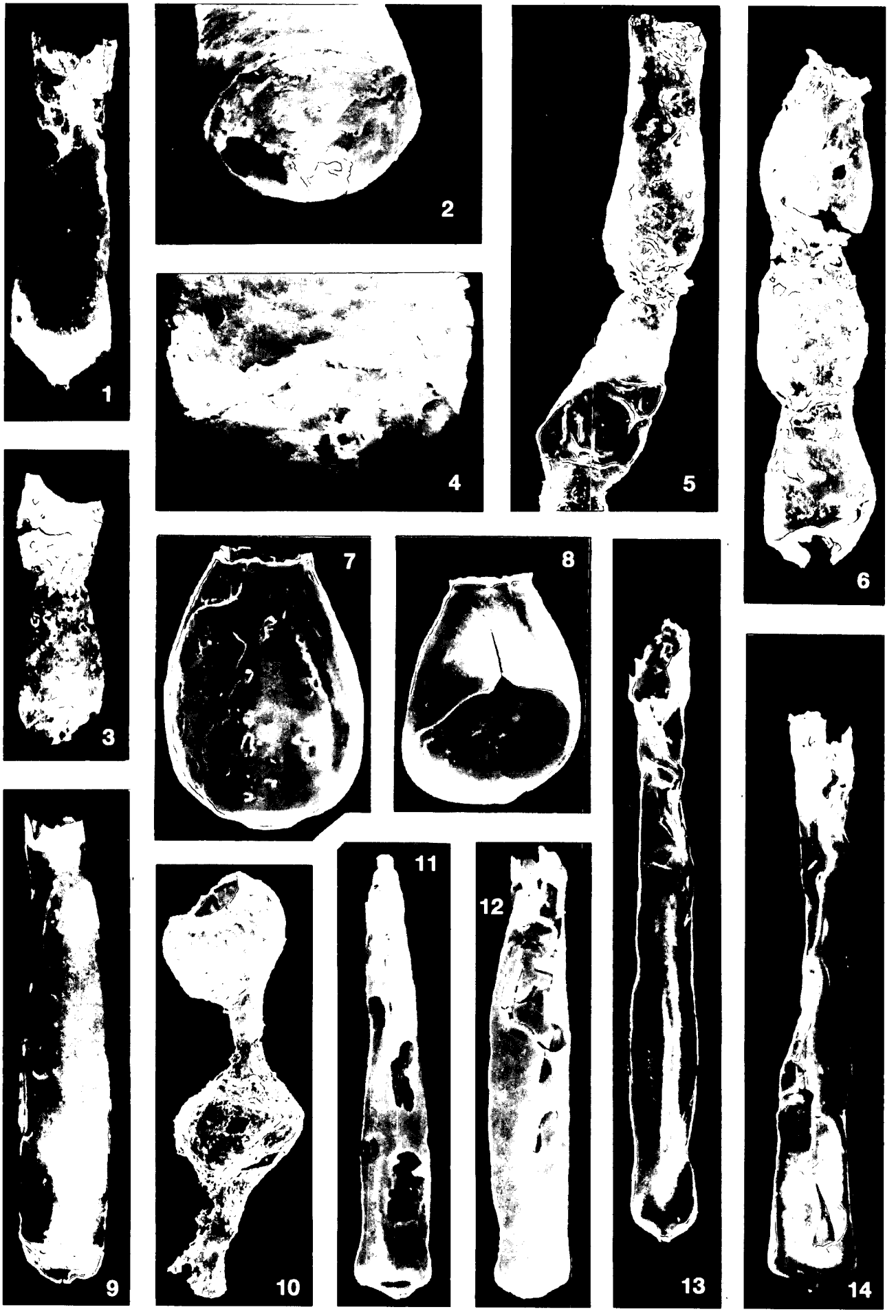
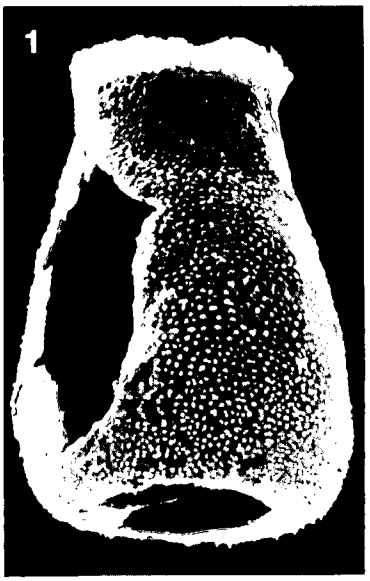


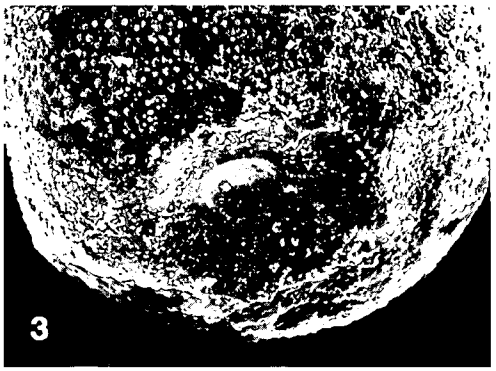
Plate 3

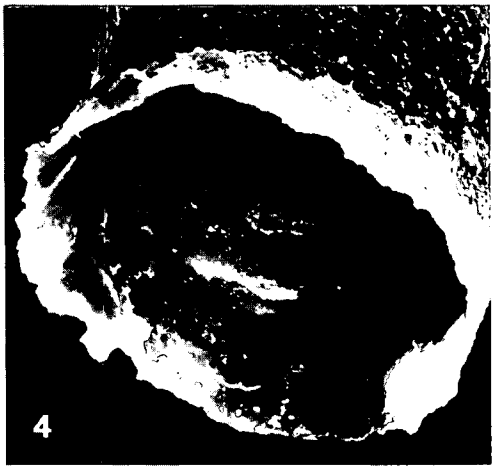
Figs. 1–5: ***Eisenackitina pregranosa* sp.nov.**
Section no. 687, sample 8, *M. chimaera* Biozone, GSP 135.
Fig. 1: ×350.
Fig. 2: Holotype; ×400.
Fig. 3: Aboral view on the specimen illustrated on Fig. 2, showing the basal scar and the basal pit; ×600.
Fig. 4: Oral view of the specimen illustrated on Fig. 1 showing a low collarette and operculum; ×600.
Fig. 5: Detail of ornamentation composed of granas and cones on the specimen from Fig. 1; ×2500.

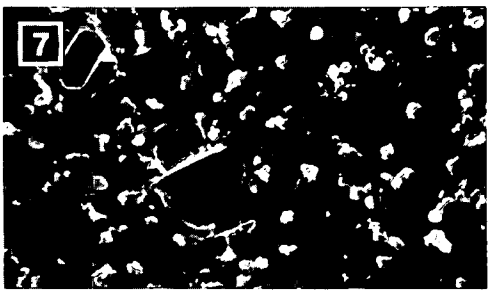
Figs. 6,9: ***Eisenackitina branikensis* sp.nov.**
Section no. 764, bed 6, sample 12, *M. dubius frequens* – G. *nassa* Interregnum, GSP-95; ×375.

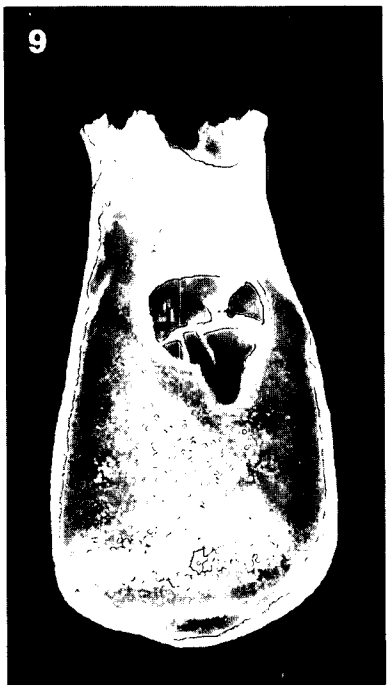
Figs. 7,8,10: ***Eisenackitina branikensis* sp.nov.**
Section no. 781, bed 7, sample 9, *M. dubius parvus* Biozone, GSP 297.
Fig. 7: Detail of tiny tuberculate to echinate ornamentation of the holotype; ×2500.
Fig. 8: ×325.
Fig. 10: Holotype; ×350.











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