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Foraminiferal assemblages in acid residues from the "Císařská rokle" Gorge at Srbsko (the Lower/Middle Devonian boundary interval, Barrandian area) and their paleoenvironmental significance

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Abstract: Thirteen foraminiferal taxa in acid residues were described from the "Císařská rokle" Gorge at Srbsko. Foraminifers were recorded only in the nodular Třebotov Limestone and their assemblages are rare and low-diversified. Assemblages dominated by *Thurammina diforamens* Ireland occur in the lowermost part of the Třebotov Limestone with shale intercalations. Assemblages with *Tolypammina* div. sp. occur in the lowermost and uppermost part of nodular limestones without shale intercalations. Among *Tolypammina* div. sp., morphotypes with whole attached tests prevailed, which may indicate higher-energy environment. Similarly to other sections from this time interval, assemblages dominated by *Ammodiscus* ex gr. *incertus* Orbigny prevailed in the middle part of the Třebotov Limestone Bimodal size distribution of their tests corresponds probably to megalo- and microspheric forms.

Key words: Foraminifera, acid-resistant microfossils, Devonian, paleoecology, Barrandian area

Introduction

The first systematic study of the Devonian foraminifers in acid residues from the Barrandian area showed that the most abundant foraminiferal assemblages occur in the interval of the Lower/Middle Devonian boundary (Holcová 2002). Also the first reports about Barrandian Foraminifera can be correlated with this time interval (Schubert and Liebus 1902, Liebus and Wahner 1904, Pokorný 1958, Petránek 1959). Outside the Barrandian area, Early and Middle Devonian foraminifers in acid residues have been described from the Holy Cross Mts., Poland (Malec 1992), Ohio (Summerson 1958), and Australia (Bell 1996, Bell et al. 2000).

In the Prague Basin, foraminifers in acid residues from this time interval were studied in detail, quantitatively analysed, and four type assemblages were distinguished using multivariate statistical methods (Holcová, in print). The following well-described sections were analysed: Prastav Quarry near Praha-Holyně, "Nad tratí" Quarry near Praha-Hlubočepy, "U jezírka" Quarry near Praha-Hlubočepy, Chýnice – abandoned quarry on the left bank of the Radotínský potok Creek, "Údolí Hluboké" Valley near Karlštejn, Kačák Creek Valley near Hostim, "Červený lom" Quarry near Suchomasty and the area of Zlatý Kůň near Koněprusy (Chlupáč 1957, 1959, 1999, 2000, Chlupáč et al. 1979).

This contribution adds this analysis of foraminiferal assemblages in acid residues from another well documented section of the "Císařská rokle" Gorge.

Material and methods

The "Císařská rokle" Gorge section situated southwest of Srbsko (Fig. 1) belongs to the most instructive sections of the Lower/Middle Devonian boundary interval. Chlupáč et al. (1979) described lithology and biostratigraphy of the section in detail (Fig. 2). It exposes a wide stratigraphic interval from the top of the Zlíchov Limestone (below 0 m of the measured section), Daleje Shale (0–11 m), Třebotov Limestone (11–31 m) with a transition from the Daleje Shale to Třebotov Limestone (11–14.5 m) and the base of the Choteč Limestone (above 31 m).

The section was sampled approximately in 1m intervals; pinpoint locations of samples are summarized in Fig. 2.

The samples were broken into small pieces (about 1 cm^3) and dissolved in 5%, 20%, and pure acetic acid.

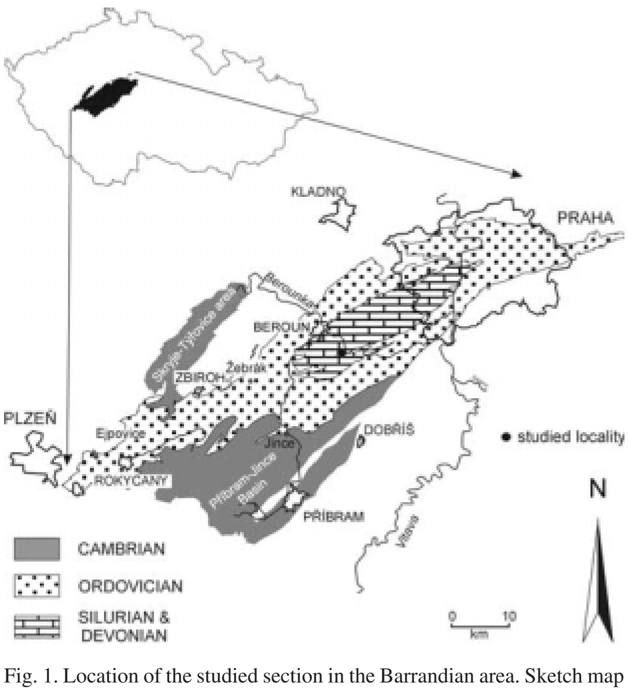


Fig. 1. Location of the studied section in the Barrandian area. Sketch map after Fatka (1999, modified).

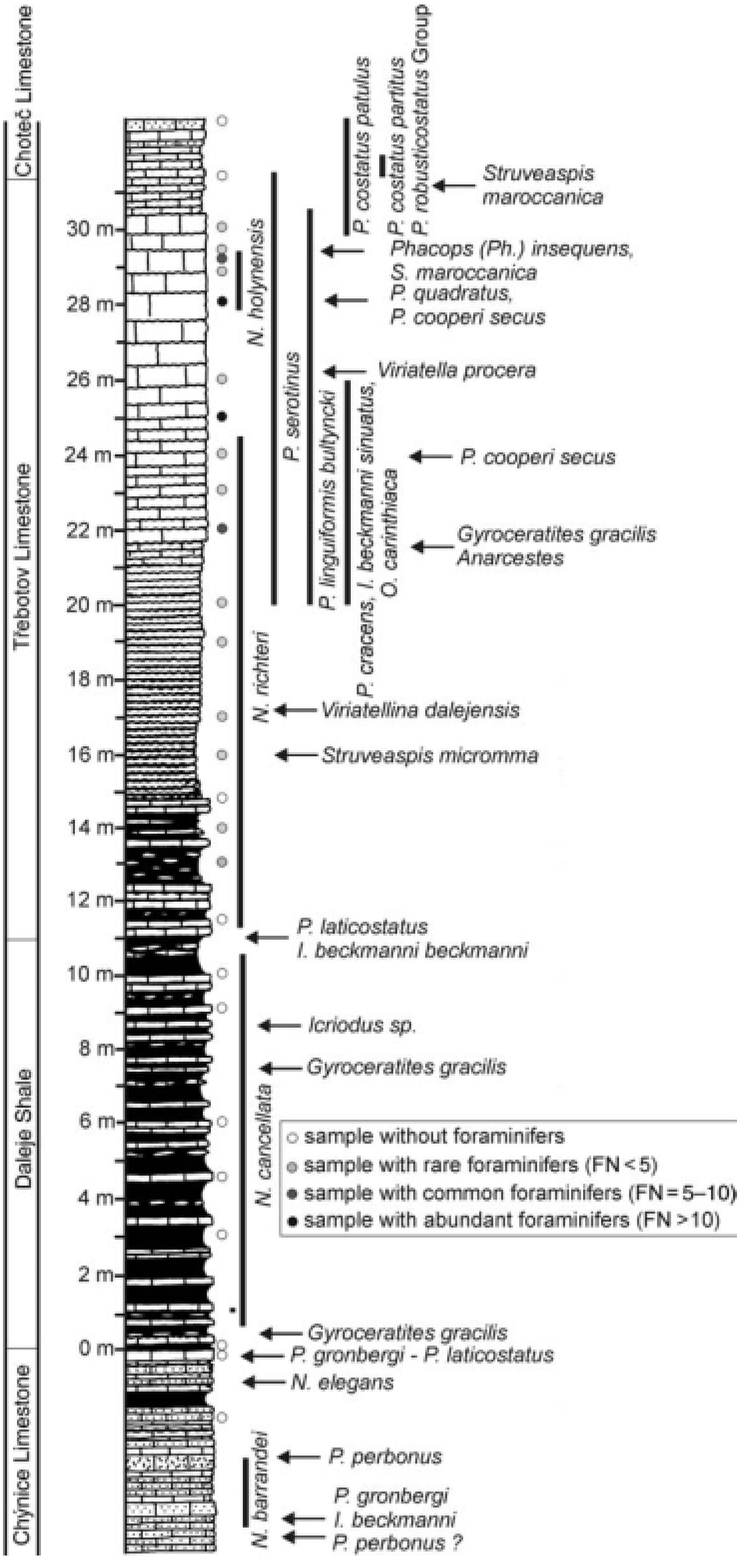


Fig. 2. Lithology, the last and the first appearance data (LAD and FAD) of biostratigraphically significant taxa and sampled intervals of the studied section. Lithology and biostratigraphic data after Chlupáč et al. (1979). FN = foraminiferal number (number of foraminifers in 1 g of rock sample).

Dissolution in pure acetic acid was realized in the closed bottles to not "dilute" acid by air moisture (Zágoršek and Vávra 2000). The most abundant foraminiferal assemblages were obtained using 20% acetic acid. Weight (in grams) of the rock sample (w_{rs}), acid residue (w_{ir}), insoluble pieces of rock (w_{rp}), and the number of foraminifers in 1 g of acid residue (A_{ir}) were recorded to calculate the abundance of foraminifers in 1 g of rock (foraminiferal number – FN):

$$FN = \frac{A_{ir} \cdot w_{ir}}{w_{rs} - w_{rp}}$$

The abundance of radiolarians was also expressed this way ("radiolarian number").

Foraminifers were separated from the acid residue > 0.63 μm in size using a stereomicroscope. SEM was used for a detailed study of test morphology. Test parameters were measured using via video system.

Results

Characteristics of foraminiferal assemblages from the "Císařská rokle" Gorge

Foraminifers in acid residues were recorded only in the red-coloured, nodular Třebotov Limestone (12.9–30 m), although a broader time interval was sampled. Relative abundances of foraminiferal taxa are summarized in Fig. 3. Generally, foraminiferal assemblages are rare, foraminiferal numbers vary from 0.3 to 19 (Fig. 4). Also diversities of assemblages are rather low: numbers of species in samples vary from 1 to 9; 13 species were recorded in the section in total.

Low diversity of foraminifers did not permit to use multivariate statistics for the analysis of the assemblages. Comparison of relative abundances of the most abundant foraminiferal taxa enables to distinguish three types of assemblages (Fig. 4): (1) Assemblages dominated by thuramminas in the interval of 12.9–17 m; (2) Assemblages dominated by tolypamminas in samples from 19 m and 30 m; (3) Assemblages dominated by *Ammodiscus* ex gr. *incertus* Orbigny in the middle and upper part of the Třebotov Limestone (samples 22–29.5 m).

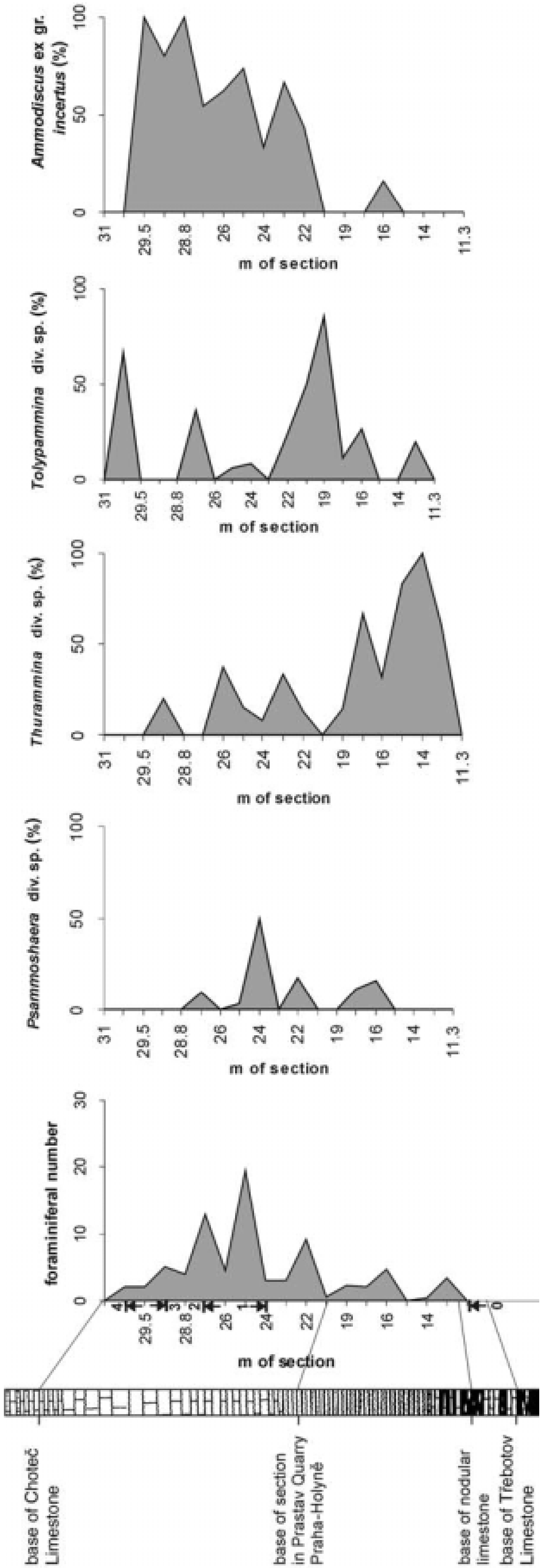
Besides foraminifers, also sponge spicules, radiolarians, tentaculites, echinoderm spines and crinoid elements were recorded in the acid residues.

Comparison with other isochronous foraminiferal assemblages in acid residues from the Barrandian area

Foraminiferal assemblages in acid residues from the "Císařská rokle" Gorge were compared with other studied assemblages from the Lower/Middle Devonian boundary interval from the Třebotov Limestone (Prastav Quarry near Praha-Holyně, "Nad tratí" Quarry near Praha-Hlubočepy, "U jezírka" Quarry near Praha-Hlubočepy,

metres	–2.6	0	0.2	3	4.6	6	9.1	10	11.3	12.9	14	14.8	16	17	19	20	22	23	24	25	26	28	28.8	29.2	29.5	30	31	31.5	33.2
Psammosphaera cava Moreman												100	13	11		40	16		48	3		9							
Psammosphaera angularis Ireland													3																
Pseudastrorhiza delicata Gutschick and Treckman													12																
Webbinelloidea hemispherica Stewart and Lampe										15				12						1									
Thurammina diforamens Ireland										42	100		28	56			11	35		5	36			21					
Thurammina elliptica Moreman										21			7	7	14		1		8	10									
Lagenammina sphaerica Moreman																	3												
Hyperammina rockfordensis Gutschick and Treckman																										34			
*Tolypammina bulbosa (*Gutschick and Treckman)																	5												
Tolypammina aff. *nodosa* Ireland																	1												
Tolypammina prodigalis (Ireland)													22	14	52	60	12		10							14			
Tolypammina aff. *sperma* Gutschick, Wiener and Young										22					34		7			6		35				52			
Ammodiscus ex gr. *incertus* Orbigny													15				44	65	34	75	63	54	100	79	100				
incertae sedis																					1	2							
foraminiferal number	0	0	0	0	0	0	0	0	0	3.3	0.3	0.5	4.7	2	2.3	0.5	9.2	3	3	19	4.5	13	4	5	2	2	0	0	0
number of counted specimens of foraminifers	0	0	0	0	0	0	0	0	0	105	28	51	102	112	90	48	104	95	114	103	120	108	96	105	108	86	0	0	0
"radiolarian number"	0	1	0	0	0	0	0	1	0	0	0	0.5	0.7	0.3	0	0.5	3.2	0	3	0.6	0	1	0	0	0	0	0	0	0
spongi spicules	x						x											x		x	x			x		x	x		x
tentaculiths	x			x		x	x				x		x	x	x				x										
crinoids												x	x	x		x		x		x	x			x	x				
echinoderms																										x			

Fig. 3. A list of acid-resistant microfossils recorded in the "Císařská rokle" Gorge.



Chýnice – abandoned quarry, "Údolí Hluboké" Valley near Karlštejn, Kačák Creek Valley near Hostim). Where biostratigraphical data were available, sections were correlated according to FADs (= the first appearance datum) and LADs (= the last appearance datum) of *Nowakia richteri* and *N. holynensis* and FAD of *Polygnathus costatus partitus* (Figs 4 and 6).

In all analysed sections foraminifers in acid residues were observed in the nodular Třebotov Limestone without shale intercalations. In the "Císařská rokle" Gorge, foraminifers were first observed also in the alternation of limestones and shales.

Diversity, abundance, species composition

Abundances of foraminifers quantified by foraminiferal number and diversity expressed by the number of species in a sample were summarized for all analysed sections from the Lower/Middle Devonian boundary interval (Fig. 5). The quantitative data were counted from approximately 100 specimens in the sample with the exception of samples with rare foraminiferal assemblages (with foraminiferal number < 0.5). Minimum, average and maximum values of these characteristics were recorded for each section. This comparison shows that foraminiferal assemblages from the "Císařská rokle" Gorge are of the lowest abundance and diversity among the assemblages from all analysed sections.

Relative abundances of the most common taxa in the "Císařská rokle" Gorge (*Psammosphaera* div. sp., *Thurammina* div. sp., *Tolypammina* div. sp. and *Ammodiscus* ex gr. *incertus* Orbigny; Fig. 4) were compared with relative abundances of these taxa in other sections (Fig. 6). The *Psammosphaera, Thurammina*, *Tolypammina* and *Ammodiscus* assemblages can be distinguished also in other isochronous sections. Particularly, then dominance of *Ammodiscus* ex gr. *incertus* Orbigny is characteristic for foraminiferal assemblages from the studied time interval.

Mutual substitution of the above mentioned assemblages in time can be compared with the section in the Prastav Quarry. In the "Císařská rokle" Gorge, the following succession of assemblages was observed: *Thurammina – Tolypammina – Ammodiscus – Tolypammina*, while in the Prastav Quarry: *Ammodiscus – Tolypammina – Psammosphaera*. Replacement of the *Ammodiscus* assemblage by the *Tolypammina* one at the level of the LAD of *N. holynensis* in both sections is well correlable. *Ammodiscus* assemblages were recorded from the upper part of the N. richteri Zone to the lower part of the N. holynensis Zone in the "Nad tratí" Quarry while in the Chýnice – abandoned quarry, *Tolypammina* assemblages occur in this interval. Similar assemblages with slight dominance of *Ammodiscus* ex gr. *incertus* Orbigny and common *Tolypammina*

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Fig. 4. Relative abundances of the most common foraminiferal taxa in the "Císařská rokle" Gorge. Lithology and bioevents after Chlupáč et al. (1979): 0 – FAD of *Nowakia richteri,* 1 – LAD of *Nowakia richteri*, 2 – FAD of *Nowakia holynensis*, 3 – LAD of *Nowakia holynensis*, 4 – FAD of *Polygnathus costatus partitus*.

	Foraminiferal number	Number of species in sample	Total number of species
Prastav Quarry	16 - 59.6 - 238	4 - 8.7 - 14	39
Chýnice – abandoned quarry	1 - 48.1 - 213	1 - 5.5 - 9	18
"U jezírka" Quarry	3 - 17.0 - 31	2 - 4.5 - 7	8
"Nad tratí" Quarry	3 - 13.0 - 25	3 - 6.0 - 9	15
"Údolí Hluboké" Valley	5 - 35.1 - 69	2 - 7.5 - 11	21
Kačák Creek Valley	2 - 15.2 - 36	2 - 4.8 - 6	15
"Císařská rokle" Gorge	0.3 - 4.6 - 19	1 - 3.5 - 9	13

Fig. 5. Maximum, average and minimum values of the foraminiferal number and the numbers of species for sections from the Lower/Middle Devonian boundary interval in the Prague Basin.

div. sp. and *Psammosphaera* div. sp. occur in the sections of "Údolí Hluboké" Valley and Kačák Creek Valley but the lack of biostratigraphic data does not allow correlation.

Relations among relative abundances of the most common taxa were analysed using correlation coefficients (Fig. 7). A significant negative correlation was obtained between the abundances of *Tolypammina* div. sp. and *Ammodiscus* ex gr. *incertus* Orbigny (correlation coefficient –0.61), which reflects mutual substitution of these taxa in assemblages. This correlation was documented also in the same time interval of other sections. These taxa are significantly the most abundant in the studied time interval in the analysed sections: they comprise 20–100 % (average 62.6 %) of the assemblages in the "Císařská rokle" Gorge and 21–81 % (average 51.4 %) in other samples. Therefore, variability of both taxa was studied.

Morphotypes of Tolypammina

Classification of *Tolypammina* representatives based on their proloculus and highly variable bent tube is very problematic. The shape of the attachment surface reflects surrounding environmental factors (Atkinson 1969). Differences used for the determination of species may be subjective: e.g., Ireland (1956) used the bending of the second chamber, type of attachment of test, presence/absence of constrictions, test size; Bell (1996) used the habit of growth, presence/absence of basal floor, differences in test surface. A classification of the Barrandian tolypamminas based on the type of test attachment and the habit of growth was proposed by Holcová (2002).

Statistical analysis of spatial distribution of foraminiferal assemblages in the Lower/Middle Devonian boundary interval in the Barrandian (Holcová, in print) suggested that the type of their test attachment may be a decisive factor for the distribution of *Tolypammina* div. sp.

To verify this hypothesis, tolypamminas were classified to four groups: (1) proloculus is hemispherical, second chamber hemitubular, so, the whole test is attached. The floor of the attachment may be missing (*T. irregularis* Blumenstengel, *T. prodigalis* (Ireland)); (2) proloculus is hemispherical, second chamber tubular (*T. sperma* Gutschick, Wiener and Young, *Tolypammina* sp.); (3) proloculus is spherical, second chamber hemitubular (*T. bulbosa* (Gutschick and Treckman)); (4) proloculus is spherical, second chamber is tubular, so, the whole test is free, or the attachment surface is small and inconspicuous (*T. polyverta* Ireland, *T. nodosa* Ireland).

In the "Císařská rokle" Gorge, attached tolypamminas significantly prevailed and notable changes in morphotype distribution in time were not recorded (Fig. 8).

Time and spatial distribution of *Tolypammina* morphotypes was compared also for other sections from the Lower/Middle Devonian boundary interval (Fig. 8). A change in time was observed only in the Prastav Quarry. Generally free or partly attached tolypamminas in the lower part of the section were replaced by attached forms occurring solely in the upper part.

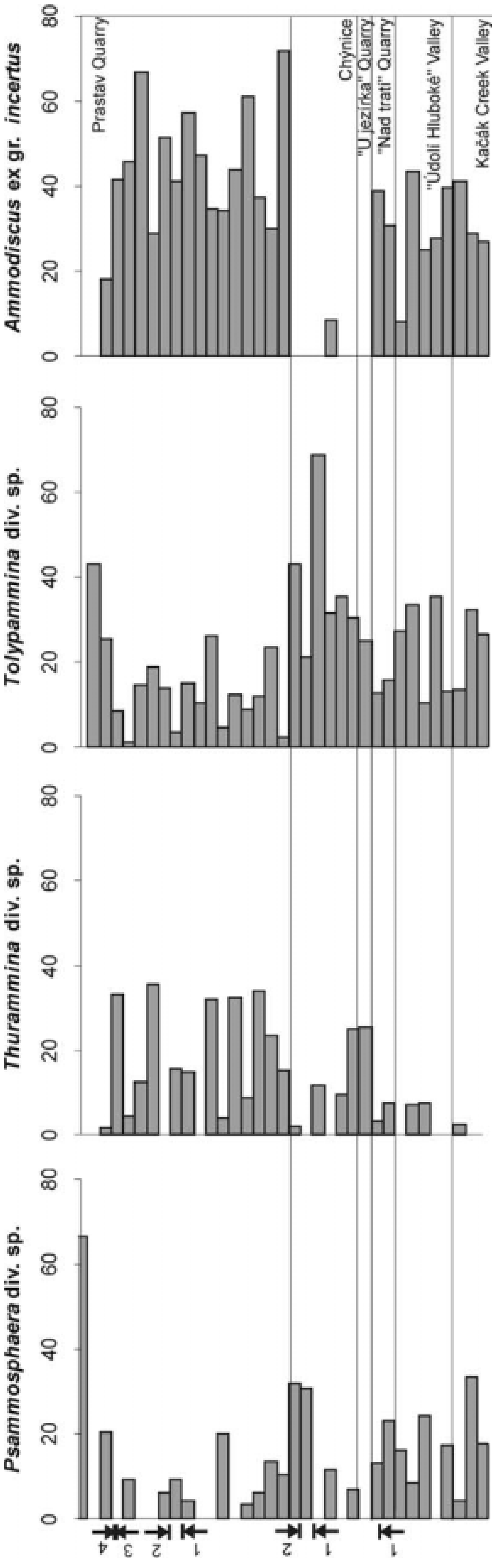
Spatial distribution of morhotypes showed that free morphotypes occur mainly in the northeastern part of the Prague Basin (sections "Nad tratí" Quarry, "U jezírka" Quarry, middle part of the Prastav Quarry). Forms with hemispherical (= attached) proloculus and tubular (= free) second chamber dominated in the central part of the basin (lower part of the Prastav Quarry, "Údolí Hluboké" valley near Karlštejn). In the northwestern part of the basin (sections Chýnice and Kačák Creek valley), forms with unattached spherical proloculus and attached hemitubular second chamber significantly prevail. Tolypamminas from the "Císařská rokle" Gorge differ in the dominance of attached forms. A shift from free forms to attached forms from the NE to the SW part of the Prague Basin can be generalized with the exception of the upper part of the Prastav Quarry.

A correlation between the relative abundance of *Tolypammina* div. sp. in foraminiferal assemblages and the abundances of individual *Tolypammina* morphotypes were analysed, but only weak correlation was obtained (correlation coefficients range from 0.18 to 0.31). Generally, the relative abundance of *Tolypammina* div. sp. increases from the NE to the SW part of the basin that correlates with a shift from free forms to attached forms.

Variability in test size of Ammodiscus ex gr. *incertus* Orbigny

The largest diameter of well-preserved tests of *Ammodiscus* ex gr. *incertus* Orbigny was measured. In the "Císařská rokle" Gorge, test diameter ranges from 0.287 to 0.518 mm, with 0.404 mm on average (Fig. 9). The histogram of test diameters shows bimodal distribution: the first indistinct peak can be recognized in the interval 0.32–0.38 mm, the second distinct peak is recorded between 0.470–0.475 mm, no values from the interval 0.39–0.42 mm were recorded. The numbers of "small" and "large" tests are similar.

The size distribution of *Ammodiscus* ex gr. *incertus* Orbigny from the "Císařská rokle" Gorge is similar to the



	Ammodiscus ex gr. *incertus*	*Tolypammina* div. sp.	*Thurammina* div. sp.	*Psammosphaera* div. sp.
Ammodiscus ex gr. *incertus*		–0.65	–0.39	–0.16
Tolypammina div. sp.	–0.61		–0.29	–0.13
Thurammina div. sp.	0.15	–0.11		–0.14
Psammosphaera div. sp.	–0.33	–0.18	–0.44	

Fig. 7. Correlation coefficients quantifying the relations between relative abundances of the most common species in the "Císařská rokle" Gorge (grey part of table) and in other sections from the Lower/Middle Devonian boundary interval (white part of table) in the Prague Basin.

size distribution from other sections from the Lower/Middle Devonian boundary interval (Fig. 9). Also the bimodal size distribution is very similar: boundaries between two size categories were recognized for tests from other sections in the interval 0.40–0.42 mm (Holcová, in print).

Unfortunately, proloculus diameter cannot be measured on the tests from the "Císařská rokle" Gorge because most of the tests were filled with sediments.

Discussion

The study of foraminiferal assemblages in acid residues from the "Císařská rokle" Gorge brought additional data on the distribution of foraminiferal taxa in the Lower/Middle Devonian boundary interval. The composition of foraminiferal assemblages confirms the previous observations that the Barrandian assemblages differ from isochronous ones from other areas: Holy Cross Mts., Poland (Malec 1992), Ohio (Summerson 1958) and Australia (Bell 1996, Bell et al. 2000).

The distribution of foraminifers in acid residues from the "Císařská rokle" Gorge confirms previous observations about the highest abundances and diversities of foraminiferal assemblages in the nodular limestones during the Devonian (Holcová 2002, in print). Based on the composition of fauna and lithology, a low-energy and deeper-water environment (below the wave base) characterized by benthic assemblages 4 to 5 *sensu* Boucot (1975) was assigned to the deposition of the Třebotov Limestone (Chlupáč et al. 1998). Kukal (1975) showed that the genesis of nodular limestones is associated with primary content of 15–25 %

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Fig. 6. Relative abundances of the most common foraminiferal taxa in the sections from the Lower/Middle Devonian boundary interval: comparison with the abundances in the "Císařská rokle" Gorge (Fig. 4). Bioevents (after Chlupáč et al. 1979): 1 – LAD of *Nowakia richteri*, 2 – FAD of *Nowakia holynensis*, 3 – LAD of *Nowakia holynensis*, 4 – FAD of *Polygnathus costatus partitus*.

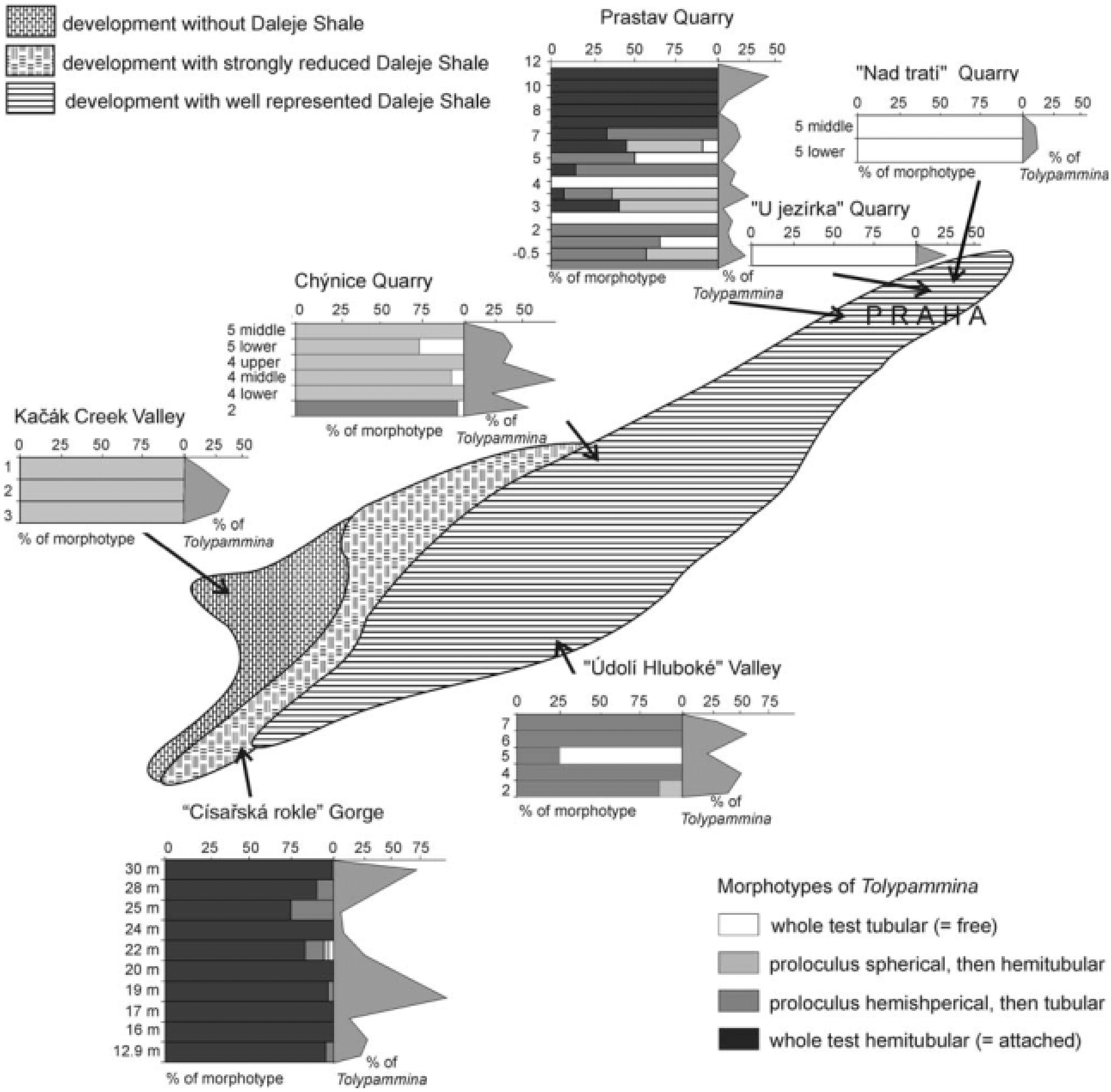

Fig. 8. Distributions of *Tolypammina* morphotypes in sections from the Lower/Middle Devonian boundary interval in the Prague Basin. Distribution of lithofacies after Chlupáč et al. (1979).

of insoluble residue (mostly clay) in calcareous muds and with diagenetic differentiation of carbonate and argillaceous components. Environmental conditions required for the genesis of nodular limestones must represent a combination of several optimum environmental factors for foraminifers in acid residues: e.g., low-energy shelf setting and content of clastic components in bottom sediments necessary for building agglutinated tests.

Foraminiferal assemblages from the "Císařská rokle" Gorge are the rarest and of the lowest diversity among the assemblages from the Early/Middle Devonian time interval in the Prague Basin. These low values may be caused by primary low-diversity, low-productivity foraminiferal assemblages or by secondary changes. Low-diversity assemblages are usually rather high-productivity (pioneer communities, r-strategists; Odum 1977); therefore, secondary impoverishment is more probable. It may be caused, e.g., by higher influx of detritus to this part of basin which "dilutes" the concentration of foraminifers in the sediment, by postmortem disintegration of fragile tests or by diagenetic changes.

What were the paleoenvironmental factors controlling the distribution of the defined *Thurammina*, *Tolypammina* and *Ammodiscus* assemblages? The *Thurammina* assemblages are characterized by low abundance and occur only in the "Císařská rokle" Gorge in the lower part of the Třebotov Limestone with shale intercalations. This facts may indicate a tolerance of *Thurammina* div. sp. (with

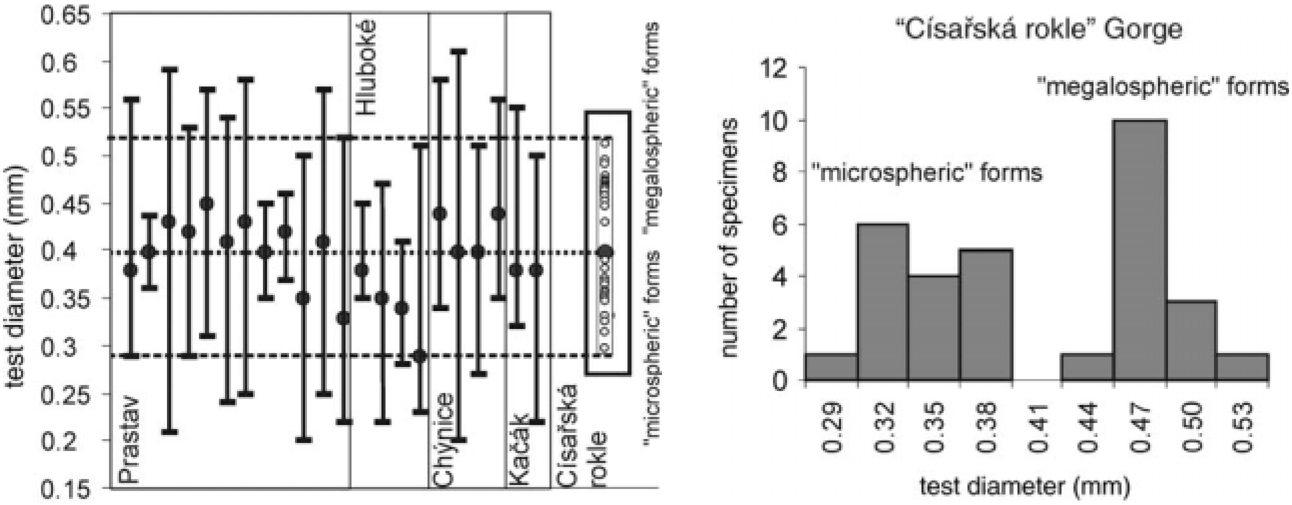

Fig. 9. Size distribution of *Ammodiscus* ex gr. *incertus* Orbigny from the "Císařská rokle" Gorge compared with minimum, average (dark circles) and maximum values of test diameters for other sections from the Lower/Middle Devonian boundary interval.

dominance of *Thurammina diforamens* Ireland) to paleoecological conditions during the deposition of couplets of limestones and clays or specific postmortem changes of assemblages suitable for the "selection" of *Thurammina* div. sp. from primary assemblages.

The dominance of *Tolypammina* div. sp. and mainly *Ammodiscus* ex gr. *incertus* Orbigny characterizes foraminiferal assemblages of the Třebotov Limestone. Mutual substitution of these taxa in assemblages expressed by high negative correlation between their relative abundances in assemblages may reflect different paleoecological requirements of both taxa.

In the Prastav Quarry (Holcová, in print), replacement of unbroken by broken *Tolypammina* tests was also observed together with increasing relative abundances of *Tolypammina* div. sp. in the uppermost part of the Třebotov Limestone. This can be well explained by higher-energy environment in the upper part of the section, which caused disintegration and postmortem transport of *Tolypammina* tests. This may be a precursor of the Basal Choteč Event (Chlupáč and Kukal 1988), which is manifested by an increase in current activity. Tolerance of *Tolypammina* to higher-energy environment agrees with the conclusions of McClellan (1966, 1973).

Data from the Prastav Quarry can be used for the interpretation of paleoecological factors which influenced the distribution of *Tolypammina* morphotypes in the Prague Basin. In the upper part of the section, three well correlable trends were recorded: an increase in relative abundances of attached forms and broken specimens among tolypamminas, and an increase in relative abundances of *Tolypammina* div. sp. in foraminiferal assemblages. From these three trends, the increase in broken specimens can be explained by higher energy of environment (see above). Then, the same reason may be responsible for the higher abundance of fully attached forms, and their tolerance to higher-energy environment can be deduced from this observation.

The general trend of spatial distribution of *Tolypammina* morphotypes (a shift from free forms to attached forms from the NE to the SW part of the Prague Basin) can be well correlated with the facies reconstruction of the basin (Chlupáč et al. 1979, 1998). Offshore facies are distributed in the eastern, southeastern and central parts of the basin. Then, free or largely free (with attached proloculus) morphotypes prevailed in the deeper part of the basin, while largely attached (with free proloculus) morphotypes prevailed in its shallower part. Fully attached forms in the "Císařská rokle" Gorge may indicate shallower environment with a higher energy. Similar spatial distribution of *Tolypammina* morphotypes was shown by multivariate statistical study of the Devonian foraminifers from the Barrandian (Holcová in print): assemblages occurring in deeper-water facies are characterized by *Thurammina* cf. *echinata* Dunn and *Tolypammina* with hemispherical proloculus and tubular second chamber (*Tolypammina* sp. 1) while assemblages recorded in shallow-water lithofacies are characterized by *Tolypammina* with spherical proloculus and hemitubular second chamber [*Tolypammina bulbosa* (Gutschick et Treckman)].

In the Pennsylvanian of Kansas, Ireland (1956) showed that the species of genera *Tolypammina* and *Ammovertella* with free tests dominated in different horizons than the species with attached tests. Bell (1996) described both morphotypes from the same samples from the Lower Devonian of Australia but reported only absence/presence data that cannot be compared with quantitative data from the Barrandian or semiquantitative data from Kansas.

Bimodal test-size distribution of *Ammodiscus* ex gr. *incertus* Orbigny also observed in the "Císařská rokle" Gorge can be interpreted in other sections from the Lower/Middle Devonian boundary interval where empty tests enable to measure also proloculus diameters. Comparison of whole test and proloculus size showed that the two size groups may correspond to megalospheric and microspheric forms (Holcová, in print). It is very probable that the two size groups from the "Císařská rokle" Gorge also represent megalospheric and microspheric forms. Based on the observation from other sections (Holcová in print), microspheric forms prevailed in unstable, higher-energy environments, megalospheric ones required stable, low-energy environments.

Taxonomical notes

Majority of the described taxa well correspond with the holotypes. Only tolypamminas *T.* aff. *sperma* Gutschick, Wiener et Young and *T.* aff. *nodosa* Ireland were named in open nomenclature because they were found only in fragments.

As no criterion was found for the separation of genera *Tolypammina* and *Ammovertella* (Holcová 2002), species originally described by Ireland (1956) like *Ammovertella prodigalis* Ireland were reclassified to genus *Tolypammina* [*T. prodigalis* (Ireland)].

Microfossils determined here as "Incertae sedis" (Plate I, Fig. 15) were already described as "Incertae sedis 1" by Holcová (2002). These microfossils are common in different paleoenvironments and stratigraphical levels in the Silurian and Devonian of Barrandian area. Their taxonomical position is questionable; their assignment to foraminifers cannot be excluded. Long tubes may indicate an infaunal organism.

Conclusions

1. Foraminiferal assemblages from acid residues from the "Císařská rokle" Gorge were recorded in the red-coloured, nodular Třebotov Limestones only. The assemblages are of low abundance and low diversity. In total, 13 species were recorded in the section. The assemblages were compared with isochronous assemblages from six sections studied in the Barrandian area.
2. The comparison of relative abundances of the most abundant foraminiferal taxa enabled to distinguish three type of assemblages in the "Císařská rokle" Gorge: (i) Assemblages dominated by *Thurammina* div. sp. recorded in the lowermost part of the Třebotov Limestone lithologically characterized by alternation of limestones and shales. (ii) Assemblages dominated by *Tolypammina* div. sp. in the uppermost and lowermost parts of the nodular Třebotov Limestone Tolypamminas may indicate more dynamic environment. (iii) Assemblages dominated by *Ammodiscus* ex gr. *incertus* Orbigny are the most characteristic for the Třebotov Limestone and occur in the middle part of nodular Třebotov Limestone probably deposited in low-energy environment.
3. Tolypamminas were classified to four groups based on the mode of test attachment: (i) whole test attached; these forms prevailed in the "Císařská rokle" Gorge; (ii) majority of tests attached, only proloculus free; (iii) majority of test free, only proloculus attached; (iv) whole test free, or attachment surface is inconspicuous. The general trend of spatial distribution of *Tolypammina* morphotypes (a shift from free forms to attached forms from the NE to the SW part of the Prague Basin) can be well correlated with the paleobathymetric reconstruction of the basin: free or largely free morphotypes (with attached proloculus) prevailed in the deeper part of the basin, largely attached morphotypes (with free proloculus) in its shallower part. Fully attached forms in the "Císařská rokle" Gorge may indicate shallower environment with a higher energy.
4. Test diameters of *Ammodiscus* ex gr. *incertus* Orbigny show bimodal distribution: the first indistinct peak can be recognized in the interval of 0.32–0.38 mm, the second peak is distinct and recorded between 0.470–0.475 mm. Numbers of "small" and "large" tests are similar. The two size groups most likely represent megalospheric and microspheric forms.

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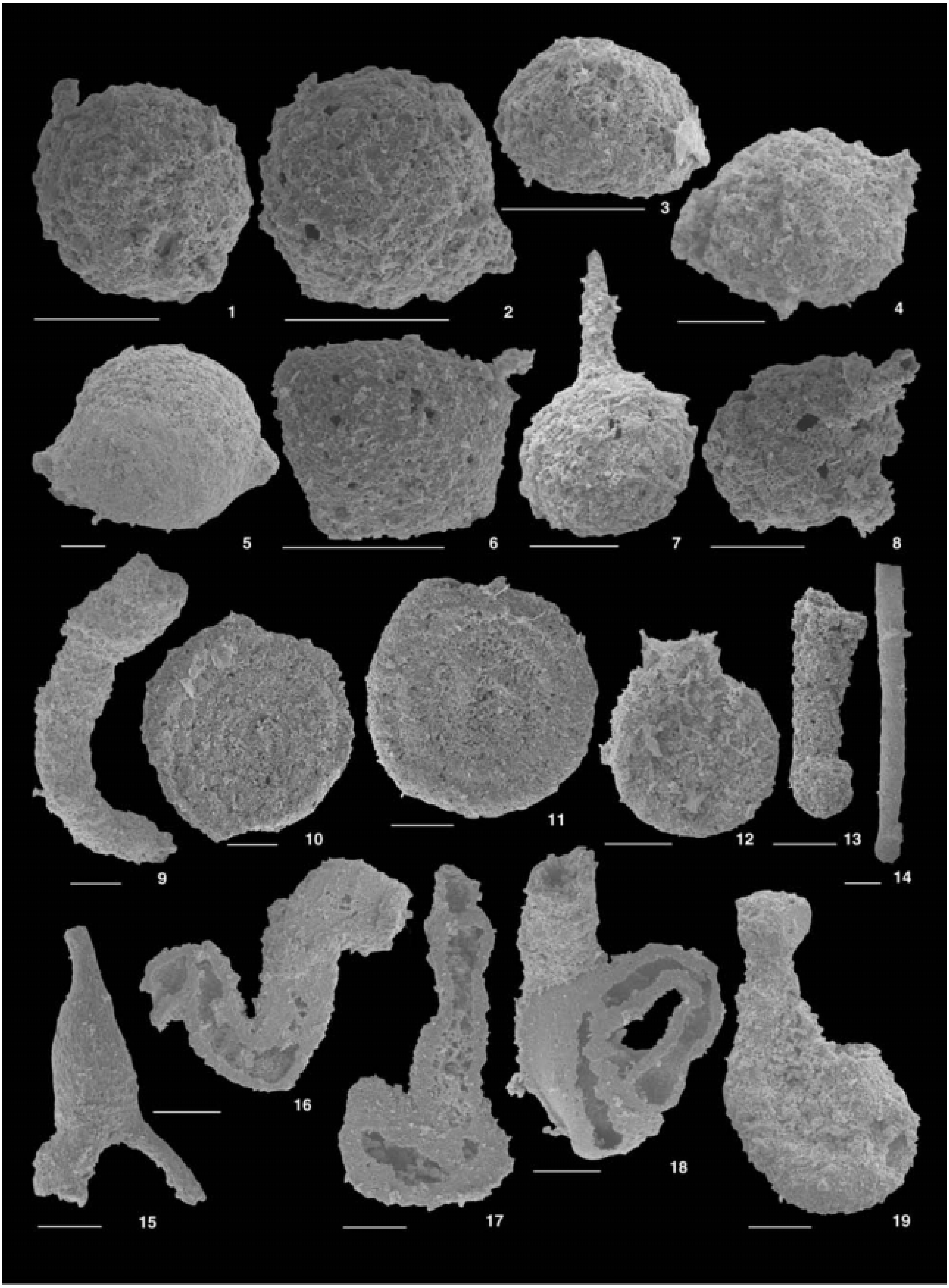
Plate I
1 – *Psammosphaera cava* Moreman, 16 m; 2 – *Psammosphaera cava* Moreman, 22 m; 3 – *Webbinelloidea hemispherica* Stewart and Lampe, 24 m; 4 – *Thurammina elliptica* Moreman, 22 m; 5 – *Thurammina diforamens* Ireland, 12.9 m; 6 – *Psammosphaera angularis* Ireland, 16 m; 7 – *Lagenammina sphaerica* Moreman, 22 m; 8 – *Pseudastrorhiza delicata* Gutschick and Treckman, 16 m; 9 – *Tolypammina bulbosa* (Gutschick and Treckman), 22 m; 10 – *Ammodiscus* ex gr. *incertus* (D'Orbigny), 22 m; 11 – *Ammodiscus* ex gr. *incertus* (D'Orbigny), 22 m; 12 – *Ammodiscus* ex gr. *incertus* (D'Orbigny), 30 m; 13 – *Tolypammina* aff. *sperma* Gutschick, Wiener and Young, 22 m; 14 – *Hyperammina rockfordensis* Gutschick and Treckman, 30 m; 15 – Incertae sedis 1, 26 m; 16 – *Tolypammina prodigalis* (Ireland), 19 m; 17 – *Tolypammina prodigalis* (Ireland), 22 m; 18 – *Tolypammina prodigalis* (Ireland), 19 m; 19 – *Tolypammina* aff. *nodosa* Ireland, 22 m. Lenght of scale bar 100 μm.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