Middle Devonian palynomorphs from southern Moravia: an evidence of rapid change from terrestrial deltaic plain to carbonate platform conditions

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Abstract: Dispersed fossil miospores and acritarchs have been recovered from the subsurface pelites in the Uhřice-1 borehole, southern Moravia. Spores of ferns, sphenopsids and lycopods with rare marine microplankton (acritarchs and chitinozoans) cysts indicate a predominantly continental environment with a limited marine influence. Dispersed miospores with cysts of unicellular marine microplankton confirm the Middle Devonian, most probably early Givetian (AD lem) age of marine transgression in southern Moravia. Thermal alteration of palynomorphs shows average values, with TAI ranging from 2+ to 3+, corresponding to 60–70 °C.

Key words: Devonian marine transgression, Moravia, basal clastics, miospores, acritarchs.

Introduction

An unmetamorphosed or slightly metamorphosed Paleozoic succession developed as continental clastics in Old Red Sandstone facies and platform carbonates of Devonian and Carboniferous ages form the sedimentary cover of an autonomous Precambrian block, the Brunovistulicum. The Brunovistulicum, or Moravo-Silesian Terrane (Pharaoh 1999), situated at the eastern margin of the Bohemian Massif, extends from the northern Austria to southern Poland. The western margin of the Brunovistulicum is incorporated into the Variscides, its eastern part is concealed beneath the Carpathian Foredeep and the Outer Western Carpathians. The northern margin abuts on the Kraków-Lubliniec Fault Zone (Fig. 1). The autochthonous sedimentary cover of the Precambrian crystalline block includes Vendian(?) to Lower Cambrian siliciclastics, mostly Lower to Middle Devonian quartzose continental "red beds", Eifelian to Frasnian platform reef sediments, Famennian to Tournaisian (but also Visean) calciturbidites, shales and platform carbonates, and mostly in allochthonous position, Upper Visean flyshoid siliciclastics. Terrestrial siliciclastics of the Moravian Karst Facies domain (Fig. 1), called colloquially basal clastics, preceed the Middle Devonian platform carbonates with coral-stromatoporoid reefs (Hladil 1985, 1988) accumulated during the basement subsidence (Bábek et al. 2007). Basal clastics occur in several linear basins in the area between Znojmo and Vratíkov, predisposed by tectonic zones with a N-S direction (Dvořák 1998). Petrological assessment of the clastics within the studied area has been done by Zádrapa & Skoček (1983), Nehyba et al. (2001) and others. Alluvial slopes, riverine valleys and fluvial depositional environment prevailed during their sedimentation as initial stages of the rifting. Quartz and arkose sandstones, deposited mainly in

environments of braid deltas, characterize similar material sources of both the Lower Cambrian and Devonian sediments (Buriánek et al. 2007). Paleontological records from the basal member of the Devonian marine sequences in southern Moravia are sparse, restricted to ichnological, palynological and paleobotanical data (Purkyňová 1978b; Jachowicz & Přichystal 1997; Mikuláš et al. 2008). At present, palynology represents the best method of differentiating between the Early Cambrian and the Devonian part of the basal clastics. Sediments suitable for the palynological studies are mostly limited to drill cores, however.

Previous paleontological investigation has been aimed predominantly at an assessment of plant macrofossils, while microfloristic records have been confined to the Late Paleozoic (Valterová 1978). Carboniferous fossil plants and miospores (Upper Visean, Namurian A) are known from the five boreholes situated between Velké Pavlovice and Slavkov (Žarošice-1, Uhřice-1 and 2; Němčičky-1 and 2; Purkyňová 1974, 1978a,b). The slightly metamorphosed slates interbedded in sandstones from the western margin of the Brunovistulian Unit NW of Brno contained miospores of the late Emsian age (*annulatus–sextantii* Assemblage Zone) together with unspecified acritarchs and scolecodonts (Jachowicz et al. 2006; Gilíková et al. 2007). The Early to Middle Devonian fossil plant remains such as fragments of coalified dichotomized axes (e.g. *Trimerophytina*) and flat thalloid possible algal remains were described from the Kozlovice SV-1, Kozlovice SV-4 and Měnín-1 boreholes (Purkyňová et al. 2004). Fragments of the early land plants have been found together with well preserved miospores indicating the Early/Middle Devonian age (late Emsian to early Eifelian). In the Měnín-1 borehole, these strata (core No. 15, depth 468–473 m) directly overlay the clastic sequences of the Early Cambrian age. The assemblage had pronounced continen-
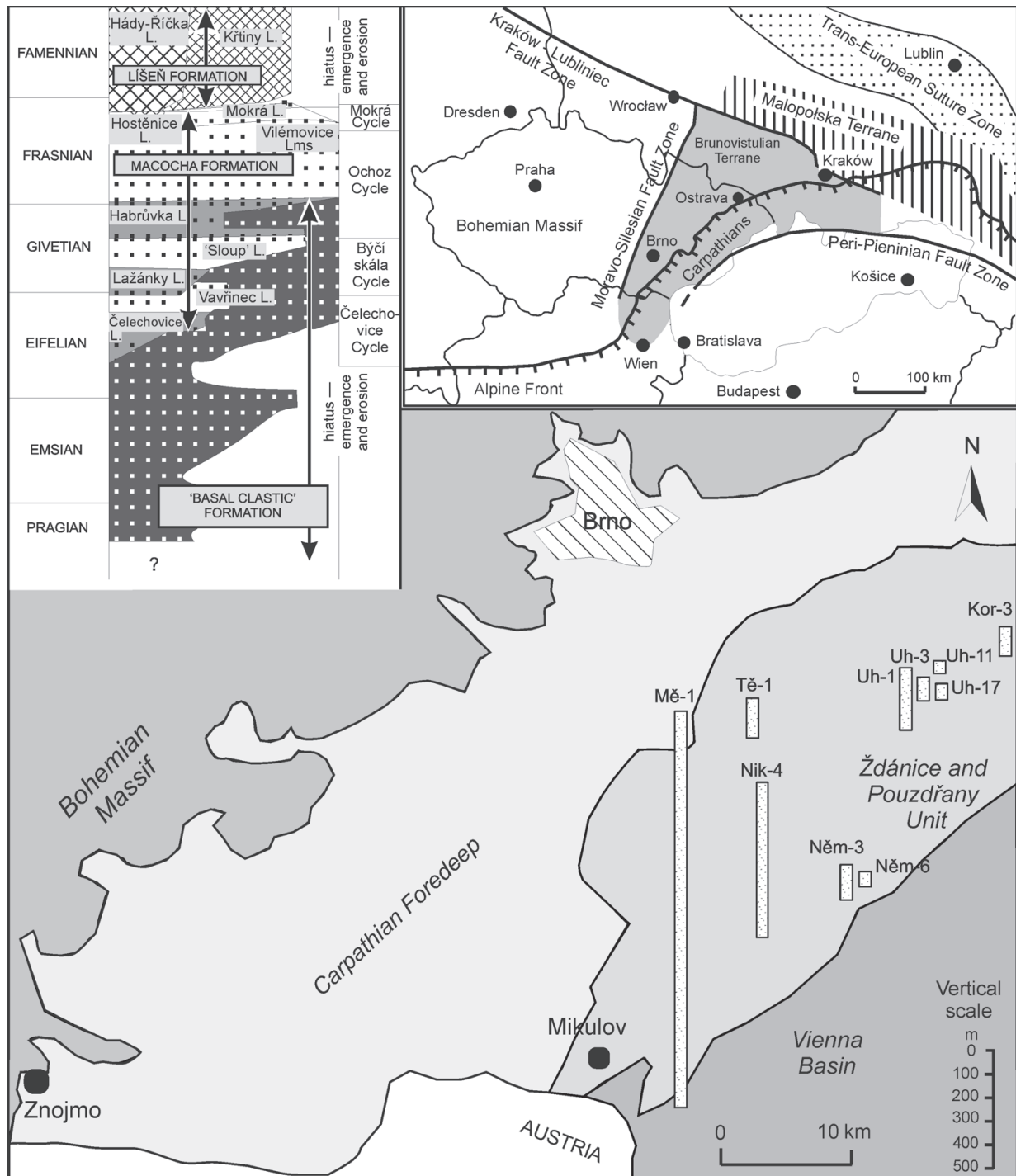
Fig. 1. Lithostratigraphy of the Devonian in the south eastern part of Moravia (modified after Hladil 1988 and Hanžl & Leichmann 1999, including the stratigraphic data from Geršl et al. 2004 and Bábek et al. 2007); geological context of Brunovistulicum (after Buła et al. 1977); location and depth of the boreholes (after Mikuláš et al. 2008).

tal chracteristics. Records of the unicellular fossil microplankton are at present confined to a single specimen of the genus *Micrhystridium*. Recovered fossil flora closely similar to paleobotanical findings from the sequences overlying the Cambrian sediments in the middle and southern part of Poland (Purkyňová et al. 2004) point to a close paleogeographical affinity between Moravia and Poland.

The presence of Middle Devonian miospores from the Uhřice-1 borehole (Drill core No. 21, depth 3596–3600 m) has been briefly recorded in several previous studies (Vavrdová & Bek 2001; Mikuláš et al. 2008). The borehole is situated ca. 50 km ESE of Brno (Fig. 1).

This paper is aimed at the detailed description of the Middle Devonian acritarch and miospore associations. Recovered pa-

lynomorphs document a rapid change from the exclusively ter-restrial depositional environment in the late Emsian to early Eifelian in the Měnín-1 borehole to strictly marine sediments of the early Givetian age. Thirty eight species of dispersed miospores, four cryptospore species and twenty three species of the fossil unicellular marine microplankton have been identified, some left in open nomenclature because of either morphological differences or a small number of specimens available.

Material and methods

Basal clastics consist of predominantly terrigenous deposits in which petromictic and quartzose conglomerates and subarcoses with abundant feldspatic detritus alternate with massive arkosic and quartz sandstones, micaceous siltstones and rare clayey shales. Bright colouring, a sign of oxidation (red-brown, light green, purple, violet, orange), and generally coarse grains make basal clastics generally not suitable for the preservation of organic-walled palynomorphs. The Uhřice-1 borehole characterizes a presence of lithofacies Sh (horizontally bedded quartzose sandstones) and lithofacies St (red-brown massive quartzose sandstones). Coarse-grained grey sandstone with silty intercalation at the depth 3596–3600 m contained ichnofossils of the genus *Planolites* Nicholson, 1879 (Mikuláš et al. 2008). Non-oxidized pelitic facies occur exceptionally. Most of the documented drill core material from the numerous boreholes drilled during the oil exploration in southern Moravia is no longer available. The drill core No. 21 (depth 3596–3600 m), relatively suitable for the preservation of palynomorphs, is exceptional in this viewpoint. The sample consists of light grey to greenish-grey silty mudstones and clayey siltstones with a splintery disintegration. Organic-walled microfossils have been isolated by conventional palynological methods (Phipps & Playford 1984). Anorganic particles have beeen removed using diluted hydrochloric acid, hydrofluoric acid and sieving. The procedure has been done by Mrs. A. Tichá in the Laboratories of the Geological Survey, Prague.

Palynological residua are dominated by various irregular fragments of resistant plant tissues. The borehole core material has been acquired in the depository of the Moravské naftové doly, a.s. Company and deposited together with palynological slides in the Institute of Geology, Academy of Science, v.v.i. (Prague).

Palynology

Palynological residue consists mainly of dispersed miospores, unicellular marine microplankton, and small irregular fragments of plant debris (tracheids, cuticles and other acid-resistant tissues).

Genera *Acinosporites* Richardson: *A. acanthomammillatus* Richardson, 1965, *A. lindlarensis* Riegel, 1968; *Apiculiretusispora* Streel: *A. brandtii* Streel, 1964, *A. plicata* (Allen) Streel, 1967; *Dibolisporites* Richardson: *D. echinaceus* (Eisenack) Richardson, 1964; and *Retusotriletes* (Naumova) Richardson: *R. rotundus* Streel, *R. distinctus* Richardson, *R. triangulatus* (Streel) Streel, 1967 prevailed in the assemblage.

Common are patinate genera *Chelinospora* Allen (*C. concinna* Allen, 1965, *C. ligurata* Allen, 1965, *C. timanica* (Naumova) Loboziak & Streel, 1989, and *Cymbosporites* Allen (*Cymbosporites catillus* Allen, 1965, *C. cyathus* Allen, 1965). The association is characterized by a proliferation of spores with irregular verrucate-clavate sculpture: *Verrucosisporites flexibilis* Turnau, 1996, *V. premnus* Richardson, 1964, *V. scurrus* McGregor & Camfield, 1982. Miospores with bifurcate spines (*Hystrichosporites corystus* Richardson, 1962, *H. microancyreus* Riegel, 1973) and pseudosaccate forms such as *Grandispora douglastownense* McGregor, 1973 were detected rarely. *Alete cryptospores* (*Retialetes* sp., *Strophomorpha ovata* Miller & Eames, 1982), and small smooth hilate forms: *Gneudnaspora divellomedia* var. *minor* Breuer et al., 2007 occur rarely. Small-sized miospores of the species *Diatomozonosporites franklinii* McGregor & Camfield, 1982, *Aneurospora goensis* Lele & Streel, 1969 and numerous smooth trilete forms complement the spectrum.

Organic-walled microfossils of marine origin are less diversified and less abundant. Twenty three species of unicellular microplankton cysts, rare scolecodonts (not identified to genera) and small-sized chitinozoans document a marine environment. Among protists, presumed green algae of the family Prasinophyceae prevail (*Cymatiosphaera* Wetzel ex Deflandre, *Leiosphaeridia* Eisenack, *Pterospermella* Eisenack, *Schismatosphaeridium* Staplin, Jansonius & Pocock). Representatives of the acritarch genus *Polyedrixium* Deunff ex Deunff (*P. embudum* Cramer, 1964, *P. arcum* Wicander & Loeblich, 1977, *P.* aff. *prismaticum* Deunff, 1966) and *Gorgonisphaeridium* Staplin et al. are quite common with more than 20 specimens. Polygonomorphids (*Veryhachium* Deunff, *Villosacapsula* Loeblich & Tappan) and nethromorphids (*Dactylofusa* Brito & Santos, *Leiofusa* Eisenack, *Navifusa* Combaz et al. ex Eisenack) are usually preserved as irregular fragments. The presence of species previously recorded from Gondwanan sites such as *Pseudolunulidia imperatrizensis* Brito & Santos, 1965, *Quadraditum ibericum* Pöthe de Baldis, 1981 and *Dactylofusa maranhensis* Brito & Santos, 1965 is remarkable.

Systematics

Acritarcha Evitt, 1963

Genus: *Polyedrixium* Deunff emend. Deunff, 1971
Type species: *Polyedrixium deflandrei* Deunff, 1954 ex
Deunff, 1961

*Polyedrixium* aff. *prismaticum* Deunff, 1966
Fig. 2.1,2

aff. 1966 *Polyedrixium prismaticum* Deunff — These, Université de Rennes, pp. 102–103, pl. 12, 107–109
aff. 1971 *Polyedrixium prismaticum* Deunff — C.I.M.P., C.N.R.S. Paris, 3, pp. 31–32, 4, 12a

Description: Hollow polyhedral vesicles with concave sides and a rhombiform outline. Facets are usually square, less often rectangular. The wall surface is scabrate to chagrenate. Edges provided with membranaceous crests with
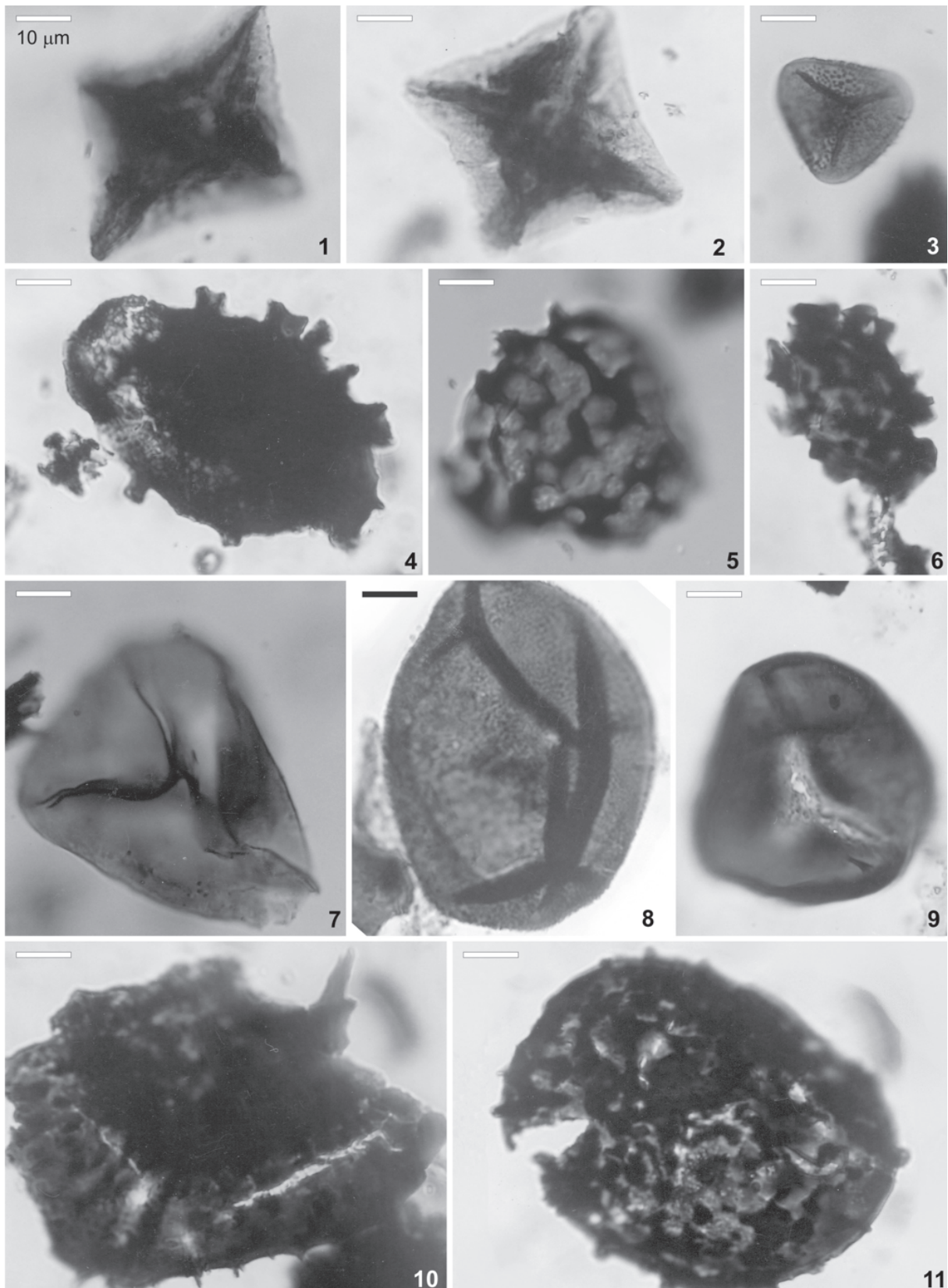
Fig. 2. 1, 2 — *Polyedrixium* aff. *prismaticum* Deunff; **3** — *Diatomozonotriletes franklinii* McGregor & Camfield; **4** — *Verrucosiporites scurrus* (Naumova) McGregor & Camfield; **5** — *Acinosporites acanthomammillatus* Richardson; **6** — *Verrucosisporites premnus* Richardson; **7** — *Leiotriletes pagius* Allen; **8** — *Apiculiretusispora plicata* (Allen) Streel; **9** — *Retusotriletes triangulatus* (Streel) Streel; **10** — *Grandispora douglastownense* McGregor; **11** — *Acinosporites acanthomammillatus* Richardson. Photo: M. Vavrdová & J. Dašková, ×1000.
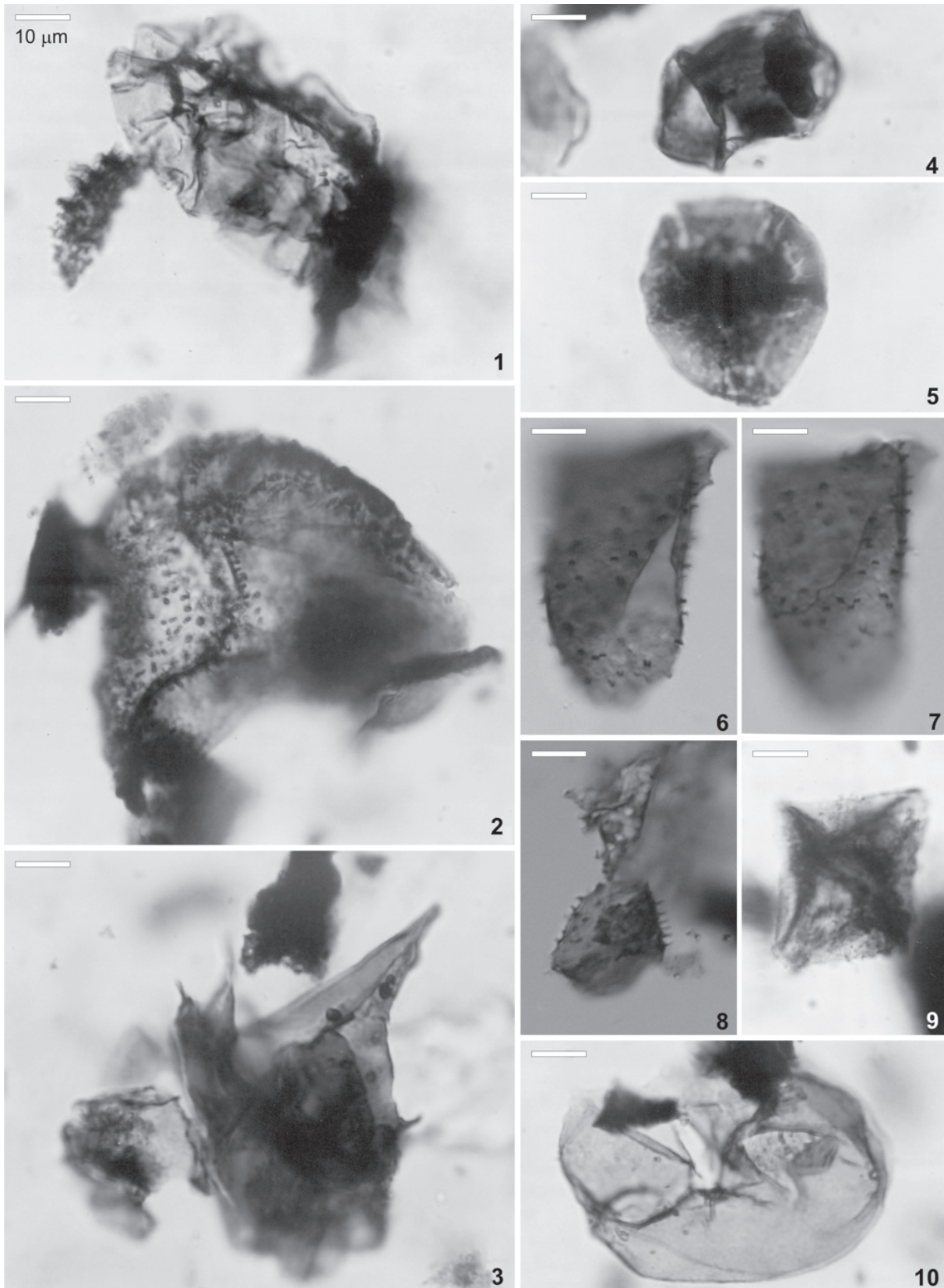
Fig. 3. **1** — A cluster of *Strophomorpha ovata* Miller & Eames; **2** — *Pseudolunulidia imperatrizensis* Brito & Santos; **3** — aff. *Stellinium comptum* Wicander & Loeblich; **4** — aff. *Quadraditum ibericum* Pöthe de Baldis; **5** — *Pterospermella* aff. *P. tenellula* Playford; **6, 7** — *Holothuriadeigma* aff. *heterakainum* Loeblich; **8** — aff. *Dactylofusa maranhensis* Brito & Santos; **9** — *Polyedrixium arcum* Wicander & Loeblich; **10** — *Leiosphaeridia tenuissima* Eisenack. Photo: M. Vavrdová & J. Dašková, ×1000.

a finely crenulate margin which run from the corners and join in the centre of the vesicle.

Dimensions: Overall size 36–(50.3)–63 µm; height of crests 3 to 5 µm (7 specimens measured).

Remarks: Specimens from southern Moravia differ from the type species mainly in larger dimensions and in the more prominent sculpture of vesicle wall. Forms from the Uhřice-1 borehole often exceed 60 micrometers, while the specimens of *Polyedrixium prismaticum* Deunff from the Canadian Couvinian attain 35 to 40 µm (Deunff 1971).

Distribution: Couvinian (Eifelian–Givetian).

Occurrence: The Uhřice-1 borehole, core No. 21; depth 3596–3600 m.

Genus: *Pterospermella* Eisenack, 1972
Type species: *Pterospermella aureolata* (Cookson & Eisenack) Eisenack, 1972

Pterospermella aff. *tenellula* Playford, 1981
Fig. 3.5

aff. 1981 *Pterospermella tenellula* Playford — Geobios 14, 2, 154, pl. 4, fig. 2-4

Description: Relatively small vesicles consisting of the dark, poorly defined central body of a roughly circular outline, and a surrounding equatorial double-walled membranous flange with an undulate margin. Few irregularly disposed radial ribs supporting the flange range from relatively massive to only slightly visible. Wall of the central body and of the equatorial flange finely granulate to echinate.

Dimensions: Central body 18–22 µm, equatorial flange 5–7 µm, rod-like thickenings up to 3 µm, overall size 36–41 µm (5 specimens measured).

Remarks: The specimens described by Playford (1981) from the Late Devonian (Givetian to Frasnian) of the Gneudna Basin, Western Australia differ in a thin-walled, diaphanous flange and a smooth wall. Emsian *Pterospermella hermosita* Cramer is smaller, more coarsely sculptured.

Occurrence: The Uhřice-1 borehole, Devonian basal clastics, core No. 21, depth 3596–3600 m.

Genus: *Quadraditum* Cramer, 1964
Type species: *Quadraditum fantasticum* Cramer, 1964
Pöthe de Baldis

aff. *Quadraditum ibericum* Pöthe de Baldis
Fig. 3.4

aff. 1981 *Quadraditum ibericum* Pöthe de Baldis — Rev. Espan. Micropaleont. 13, p. 248, pl. 8, fig. 1

Description: Thick-walled hollow central body of rectangular or square outline and psilate vesicle wall. Pillow-shaped opaque central body protrudes in corners into short hollow tubular projections, opened into central cavity and connected with two opposite thin bladder-like periderm envelopes. Wall of periderm smooth, thin, uni-layered, transparent. Overall outline elongately ovoidal to ellipsoidal.

Size range: Central body: 24 µm; overall size: 40 µm (1 specimen measured).

Remark: Relatively poor preservation of the single specimen studied does not allow an unequivocal determination.

Distribution: Los Espejos Formation, San Juan Province, Argentina (Pöthe de Baldis 1981).

Occurrence: The Uhřice-1 borehole, core No. 21, depth 3596–3600 m.

Genus: *Holothuriadeigma* Loeblich, 1970
Type species: *Holothuriadeigma heterakainum* Loeblich, 1970

Holothuriadeigma aff. *H. heterakainum* Loeblich, 1970
Fig. 3.6,7

aff. 1970 *Holothuriadeigma heterakainum* Loeblich — Proc. North Amer. Paleont. Conv. Chicago 1969, 722–23, pl. 16A–C
aff. 1971 *Dactylofusa* 'neahgae' Cramer — Rev. Espanol. Micropaleont. 1, 82, pl. 2

Description: Vesicle hollow, naviform to reniform in shape with broadly rounded poles. Central body single-walled, wall thin, transparent, finely scabrate. The ornamentation consists of short thorn-like spines or flexible processes distributed evenly on a vesicle surface, with a tendency to form longitudinal ridges. Distal terminations of processes range from sharp tips to blunt or bifurcate tips. Processes seem to communicate with the vesicle interior. Excystment is performed by a straight rupture of the central body.

Size range: Length around 35 µm, width 25 µm; length of processes 4–6 µm (3 specimens measured).

Remark: The recovered specimen differs from the species *Dactylofusa maranhensis* Brito & Santos mainly in broadly rounded polar areas. *Dactylofusa fastidiona* (Cramer) Combaz et al. and *Rhachosoarium lappaceum* Tappan & Loeblich from the Late Ordovician of the USA are similar in shape, but differ in an absence of bifurcate spines (Tappan & Loeblich 1971). *Holothuriadeigma heterakainum* Cramer differ in stouter, longer sculptural elements.

Distribution: Middle Silurian Neahga Shale, New York, Ontario (Loeblich 1970; Cramer 1971).

Occurrence: Devonian basal clastics, Uhřice-1 borehole, core No. 21, depth 2596–3600 m.

Genus: *Pseudolunulidia* Brito & Santos, 1965

Pseudolunulidia imperatrizensis Brito & Santos, 1965
Fig. 3.2

1965 *Pseudolunulidia imperatrizensis* Brito & Santos — Notas Prelim Estud., Div. Geol. Min 129, p. 12, pl. 2 (non vidi)
1967 *Pseudolunulidia imperatrizensis* Brito — Micropaleontology 13, p. 486, pl. 3/1

Description: Half-moon shaped vesicle with broadly rounded extremities. Wall thin, transparent, unilayered. Ornamentation consists of short solid rods evenly and densely distributed on vesicle surface. Distal terminations of sculptural elements sharp, blunt or capitate.
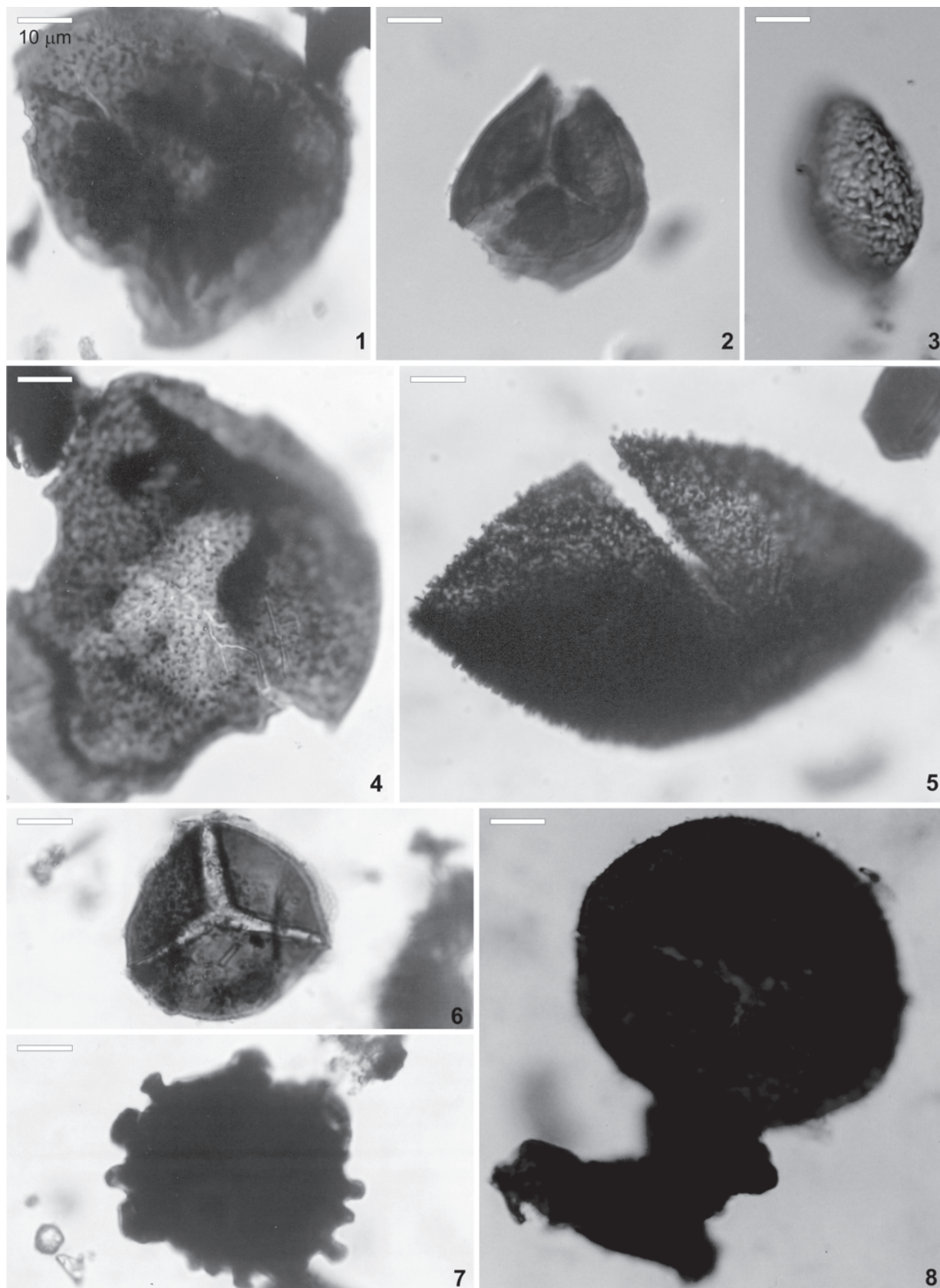
Fig. 4. 1 — *Apiculiretusispora gaspiensis* McGregor; **2** — *Geminospora punctata* Owens; **3** — aff. *Rugosphaera tuscarorensis* Strother & Traverse; **4** — *Apiculiretusispora brandtii* Streel; **5** — *Acinosporites lindlarensis* Riegel; **6** — *Perotrilites pannosus* Allen; **7** — *Verruco-sisporites flexuosus* Turnau; **8** — unidentified opaque miospore. Photo: M. Vavrdová & J. Dašková, ×1000.

Size range: 72 μm; height of rods and rod-like projections up to 3 μm (1 specimen measured).

Distribution: Middle Devonian, Brazil (Brito & Santos 1965).

Occurrence: The Devonian basal clastics, Uhřice-1 borehole, core 21, depth 2596–3600 m.

Cryptosporites Richardson, Ford & Parker, 1984

Genus: *Rugospora* Strother & Traverse, 1979
Type species: *Rugospora tuscarorensis* Strother & Traverse, 1979

aff. *Rugosphaera tuscarorensis* Strother & Traverse, 1979
Fig. 4.3

aff. 1979 *Rugosphaera tuscarorensis* Strother & Traverse — Palynology 3, p. 6, pl. 1, figs. 1–3
aff. 2006 unidentified palynomorph, Wellman — Trans. R. Soc. Edinburgh, Earth Sci. 97, figs. 20k–m, o–q

Description: Inaperturate palynomorphs occur as monads of oval shape, outline smooth, surface covered by irregular meshwork of external vermiculate/cristate/rugulate elements. Ridges irregular, thin to relatively thick, tend to form elongate reticulum or concentric ridges near the equator.

Size range: Length 30–42 μm; width 20–25 μm (3 specimens measured).

Remark: Oval shape and relatively thin wall distinguish the Moravian specimen from the Silurian cryptospores.

Distribution: Tuscarora Formation, Pennsylvania (Strother & Traverse 1979).

Occurrence: The Devonian basal clastics, the Uhřice-1 borehole, core No. 21, depth 3596–3600 m.

Stratigraphy

Biostratigraphical assessment has been based mainly on the abundant presence of miospores with prominent verrucate-clavate sculpture such as *Raistrikia aratra* Allen, *Verrucosisporites flexibilis* Turnau (Fig. 4.7), *V. premnus* Richardson (Fig. 2.6) and *V. scurrus* (Naumova) McGregor & Camfield (Fig. 2.4) as well as abundant patinate types, which do not appear before the Givetian Stage (Turnau & Racki 1999; Zhu et al. 2008). The representatives of the thick-walled camerate genus *Geminospora* such as *G. lemurata* Balme emend. Playford and *Geminospora punctata* Owens (Fig. 4.2) although not very abundant, make the late Eifelian age less probable (Paris et al. 1985; Loboziak et al. 1990, 1991). On the other hand, absence of *Samarisporites triangulatus* Allen precludes an age younger than the early Givetian.

With some reserve, the age of the recovered palynospectra can be identified with the early Givetian AD lem zone of the scheme established by Streel et al. (1987) in the type Devonian marine deposits of the Ardenne-Rhenish region or to the *lemurata-magnificus* miospore palynozone of Richardson & McGregor (1986). The age of palynomorphs from the Uhřice-1 borehole corresponds to the de Blacourt Formation

(Boulonnais, France; Brice et al. 1979) and Srbsko Formation (Raskatova & Jurina 2008).

The onset of the marine transgression in southern Moravia is coeval with the major facies change in the Teplá-Barrandian Zone, where the sedimentation of carbonates is gradually substituted by pelitic or alternatively pelitic/carbonate facies. The age of the marine transgression in the Moravian Karst facies was determined by study of the carbonate intercalations in the uppermost part of clastic sequences (Zukalová et al. 1981; Hladil 1985). At the base of the carbonate sequence in the Měnín-1 borehole, at a depth of 397.6–398.9 m, a Givetian rugose coral fauna has been identified (Galle in Zukalová et al. 1981). In the Tišnov area to the NW of Brno organic-walled marine microfossils appear/occur earlier, together with dispersed miospores of the late Emsian (Dalejan) age (Jachowicz et al. 2006).

Discussion

The initial Devonian sedimentary sequences originated in a variegated environment, ranging from riverine valleys and alluvial slopes to near-shore deltas (Nehyba et al. 2001). In some parts, their petrology and sedimentary textures are similar to the underlying sedimentary sequences of the Early Cambrian age, as they probably originated in similar settings (Mikuláš et al. 2008). Devonian clastics are generally more mature and they evidently originated in different paleolatitudes and paleoenvironments. Fossil plants occur in autochthonous facies of near-shore swamps and supratidal marshes, closely connected with the formation of the coal seams. Miospores are derived from such plant genera as *Calamophyton* Kräusel & Weyland (*Dibolisporites echinaceus* (Eisenack) Richardson), *Psilophyton* Dawson (*Retusotriletes* Naumova, *Apiculiretusispora plicata* (Allen) Streel), *Sawdonia* (*Retusotriletes* Naumova, *Apiculiretusispora brandtii* Streel) and *Tetraxylopteris* Beck (*Rhabdosporites langii* (Eisenack) Richardson; Richardson 1964; McGregor 1977). Representatives of sphenopsids were abundant: *Dibolisporites* and *Hystricotriletes*. The species *Geminospora lemurata* (Balme) Playford and genus *Rhabdosporites* indicate presence of the progymnosperm *Archaeopteris* Dawson.

The thermal maturity of recovered palynomorphs has been assessed with the use of the five-point scale based on irreversible gradual colour variation of the polymeric cell wall ranging from light yellow to dark brown (Staplin 1977; Utting & Hamblin 1991). The thermal alteration index of Devonian palynomorphs ranges from 2+ to 3+. Generally, thick-walled miospores were more affected than thin cell wall of acritarchs. Post-diagenetic alteration of individual specimens greatly varies within a single palynological residue. Despite a relatively strong thermal alteration, the number of identifiable specimens has been satisfactory for a specific determination. All specimens of the Devonian age have been more intensively heated than much less affected palynological assemblages of the Early Cambrian age from the neighbouring Měnín-1 and Němčičky-3 boreholes (Fig. 1), where the post-diagenetic alteration did not exceed TAI 1+.

Recovered dispersed miospore associations correspond well with coeval palynofloras from the microfloral assemblages described from the northern Gondwana (Paris et al. 1985; Loboziak et al. 1988, 1992; Loboziak & Streel 1989; Grignani et al. 1991; Breuer et al. 2007), as well as from the Artic and North Atlantic region (Richardson 1964; Allen 1965), and Central Europe (Brice et al. 1979; Loboziak & Streel 1981; Loboziak et al. 1990). The Givetian miospore association characterizes a large proliferation of miospores with prominent verrucate/clavate sculpture elements (Fig. 2.4,5,6), presence of small species *Diatomozonotriletes franklinii* McGregor & Camfield (Fig. 2.3), and appearance of progymnosperms (Geminospora). Such a general similarity most probably coincides with a presumed homogeneity of microfloral assemblages from paleoboreal to paleotropical regions in the Middle Devonian (Loboziak & Streel 1989; Streel et al. 2000). A relatively distant similarity can be found between the palynomorphs from Uhřice-1 borehole and the miospore assemblages of the Early/Middle Devonian age recorded by Turnau (1974) from the Radom-Lublin area in southern Poland, where early Givetian is absent. On the other hand, 15 miospore species are common with palynomorph assemblages described from the late Eifelian-early Givetian deposits from the subsurface of Western Pomerania (Turnau 1996) and of the Achanarras Horizon, Orcadian Basin (Richardson 1964). Moravian forms connect with the Old Red Sandstone associations relatively large dimensions of some spores such as *Apiculiretusispora brandtii* Streel (up to 0.1 mm), a proliferation of species with large irregular verrucate-clavate sculpture and a reduced amount of cavate forms. Both localities are characterized by abundant presence of miospores with sculpture of biform elements, and retusoid forms. Ten miospore species occur both in southern Moravia and in the Barrandian Roblin Beds, Srbsko Formation (early Givetian). The miospore associations from the Barrandian area (Hlubočepy section, Czech Republic) differ in mass occurrence of representatives of genus *Geminospora* (Yurina et al. 2009).

Several long-ranging species of dispersed miospores such as *Apiculiretusispora brandtii* Streel, *Samarisporites eximius* (Allen) Loboziak & Streel and *Rhabdosporites langii* (Eisenack) Richardson occur jointly in the Uhřice-1 borehole and in the miospore assemblages recovered from the Měnín-1, Kozlovice SV-1, and Kozlovice SV-4 boreholes by Purkyňová et al. (2004). Coalified axes of genera *Psilophyton* and *Hostimella* of Middle/Late Devonian age and dispersed miospores of the late Emsian to early Eifelian age. In this level, unicellular microfossils are confined to a single specimen of the genus *Micrhystridium*. The Uhřice-1 associations differ in the presence of marine microfossils.

SPORES	Remarks
Acinosporites acanthomammillatus Richardson, 1965	Fig. 2.5,11
Acinosporites apiculatus (Streel) Streel, 1967	
Acinosporites lindlarensis Riegel, 1968	Fig. 4.5
Anapiculatisporites petilus Richardson, 1965	
Aneurospora goensis Lele & Streel, 1969	
Apiculiretusispora arenorugosa McGregor, 1973	
Apiculiretusispora brandtii Streel, 1964	Fig. 4.4
Apiculiretusispora gaspiensis McGregor, 1973	Fig. 4.1
Apiculiretusispora plicata (Allen) Streel, 1967	Fig. 2.8
Chelinospora concinna Allen, 1965	
Chelinospora ligurata Allen, 1965	
Chelinospora timanica (Naumova) Loboziak & Streel, 1989	
Convolutispora disparalis Allen, 1965	
Convolutispora mimetensis (Vigran) Allen, 1965	
Cyclogranisporites rotundus (Naumova) Allen, 1965	
Cymbosporites catillus Allen ,1965	
Cymbosporites cyathus Alen, 1965	
Diatomozonotriletes franklinii McGregor & Camfield, 1982	Fig. 2.3
Dibolisporites echinaceus (Eisenack) Richardson, 1964	
Dibolisporites pilatus Breuer et al., 2007	
Geminospora lemurata Balme emend. Playford, 1983	
Geminospora punctata Owens, 1971	Fig. 4.2
Leiotriletes pagius Allen, 1965	Fig. 2.7
Grandispora douglastownense McGregor, 1973	Fig. 2.10
Hystrichosporites corystus Richardson, 1962	
Hystrichosporites microancyreus Riegel, 1973	
Lophozonotriletes dens-draconis Taugourdeau-Lantz, 1967	
Perotrilites pannosus Allen, 1965	Fig. 4.6
Raistrikia aratra Allen, 1965	
Retusotriletes actinomorphus Chibrikova, 1962	
Retusotriletes distinctus Richardson, 1965	
Retusotriletes triangulatus (Streel) Streel, 1967	Fig. 2.9
Rhabdosporites langii (Eisenack) Richardson, 1960	
Rhabdosporites minutus Tiwari & Schaarschmidt, 1975	
Samarisporites eximius (Allen) Loboziak & Streel, 1988	
Verrucosisporites flexuosus Turnau, 1996	Fig. 4.7
Verrucosisporites premnus Richardson, 1964	Fig. 2.6
Verrucosisporites scurrus (Naumova) McGregor & Camfield, 1982	Fig. 2.4
CRYPTOSPORES	
Gneudnaspora divellomedium var. *minor* Breuer et al., 2007	
Scylaspora rugulata (Riegel) Breuer et al., 2007	
Strophomorpha ovata Miller & Eames, 1982	Fig. 3.1
aff. *Rugosphaera tuscarorensis* Strother & Traverse, 1979	Fig. 4.3
MICROPLANKTON	
Cymatiosphaera cladora Wicander & Wood, 1997	
Baiomeniscus camurus Loeblich, 1970	
aff. *Dactylofusa maranhensis* Brito & Santos, 1965	Fig. 3.8
Evittia sommeri (Brito) Sarjeant & Vavrdová,1997	
Gorgonisphaeridium disparatum Playford, 1977	
aff. *Horologinella wicanderi* Martin, 1985	
Holothuriadeigma heterakainum Loeblich, 1970	Fig. 3.6,7
Leiofusa irroratipellis Loeblich, 1969	
Leiosphaeridia ketchenata Turner, 1984	
Leiosphaeridia tenuissima Eisenack, 1958	Fig. 3.10
Lophosphaeridium dumalis Playford, 1977	
Polyedrixium arcum Wicander & Loeblich, 1977	Fig. 3.9
Polyedrixium embudum Cramer, 1964	
Polyedrixium aff. *prismaticum* Deunff, 1966	Fig. 2.1,2
Pseudolunulidia imperatrizensis Brito & Santos, 1965	Fig. 3.2
Pterospermella sp. aff. *P. tenellula* Playford, 1981	Fig. 3.5
Pterospermella reticulata Loeblich & Wicander, 1976	
aff. *Quadraditum ibericum* Pöthe de Baldis, 1981	Fig. 3.4
Schismatosphaeridium algerense Cramer & Diéz, 1976	
aff. *Stellinium comptum* Wicander & Loeblich, 1977	Fig. 3.3
Umbellasphaeridium deflandrei Moreau-Benoit, 1967	
Veryhachium trispinosum (Eisenack) Stockmans & Williere, 1962	
Villosacapsula helenae (Cramer) Loeblich & Tappan, 1976	
CHITINOZOANS	
Fungochitina pilosa (Collinson & Scott)	
Hoegisphaera sp.	
Plectochitina sp.	

Unicellular marine microplankton include a large variety of species widespread, for example, in Western Europe, northern Africa. The uppermost part of basal clastics is marked by a transition to off-shore coral-reef carbonate sedimentation, indicated by intercalations in clastics (Hladil 1985).

Results

The unicellular marine microplankton of the Middle Devonian age has been recovered from a single sample of the clayey siltstone from the Uhřice-1 borehole, southern Moravia. Twenty three species have been identified, together with thirty eight taxa of dispersed spores. Fossil plants occur in autochthonous facies of near-shore swamps and supratidal marshes. Moravian Middle Devonian phytocoenoses apparently enjoyed a warm, humid climate, affected by marine ingression. On the other hand, organic-walled marine microfossils, although poorly preserved, show affinities to the Gondwanan regions in the presence of such forms as *Pseudolunulidia imperatrizensis* Brito & Santos and *Quadraditum ibericum* Pöthe de Baldis. The presence of diversified cysts of marine microplankton confirms the timing of the transition from an exclusively terrestrial depositional environment to marine conditions within the Moravian Karst Facies domain. The low abundance of fossil marine microplankton together with a prevalence of thin-walled sphaeromorphs indicate the nearshore, most probably brackish environment, with a limited influence of marine conditions.

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