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New flora from the Permian of the Intrasudetic Basin, Poland

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Abstract

A floral assemblage was collected from a new Polish locality (Janików) situated on the Czech-Polish border in the Intrasudetic Basin. It was found in the lower Permian (Asselian) Ruprechtice Horizon, of the Olivětín Member, Broumov Formation. The plant fossils were usually fragmentary, and the following taxa were determined: *Alloiopteris* aff. *erosa, Nemejcopteris feminaeformis, Senftenbergia* sp., *Lobatopteris* sp., *Sphenopteris* sp., *Cyathocarpus* cf. *densifolius, Lobatopteris* cf. *geinitzii, Lobatopteris* nov. sp., *Dicksoniites* cf. *plukenetii, Autunia conferta, Cordaites* sp. and seeds. *Alloiopteris* was first recorded in the Permian. The assemblage is composed predominantly of ferns and pteridosperms that tend to be hygrophilous to mesophilous floral elements. The flora from the Otovice and Ruprechtice horizons is usually rich in walchian conifers and peltasperms (*Autunia conferta*), and so the Janików flora is quite different with its hygrophilous elements. The fragmentary preservation suggests long transport distances, and probably only the remains of flora growing on the lakeshore were deposited in the calcareous bituminous shales. This coastal vegetation probably formed a barrier to mesophilous plants growing further from the lake, so their fragments are more sporadic.

1. INTRODUCTION

The first report on the Intrasudetic Basin by ZOBEL & CARNALL (1831-1833) recognized its basin structure but could only differentiate the Carboniferous and Permian using the presence of grey and red sediments. Developing a clear stratigraphy for the Intrasudetic Basin took a long time (KREJČÍ, BEYRICH, JOKÉLY, O. FEISTMANTEL, STUR and WEISS), and most of these works concerned the Carboniferous "coal-bearing" deposits. Individual plant species were described from the Permian deposits: e.g., *Autunia conferta* (STERNBERG) KERP (STERNBERG, 1825), or *Taeniopteris coriacea* GÖPPERT and *T. falax* GÖPPERT (GÖPPERT, 1864/1865), but a full monograph of the Intrasudetic Basin Permian flora has still to be written.

Since GÖPPERT (1864-1865), the Permian flora of the eastern part of the Intrasudetic Basin has not been systematically studied. NĚMEJC (1953) mentioned a list of 10 species from the localities Olivětín, Otovice and Ruprechtice, (Broumov Formation, Olivětín Member). Interest in the Intrasudetic Basin increased in the 1960s due to geological mapping, and RIEGER (1966) listed 22 species from the Olivětín Member (in TÁSLER et al., 1966). ŠETLÍK in TÁSLER et al. (1979) gave essentially the same list as in NĚMEJC (1953). BORS (1988) was the last researcher who studied the Olivětín Member flora in detail and expanded the floral list by six species, but the first author regards some of them as questionable. In the Polish part of the Intrasudetic Basin, the flora has been documented by LIPPS (1927) from the Permian locality Unisław Śląski (Langwaltersdorf).

Collections of the National Museum in Prague, the East Bohemian Museum in Hradec Králové (S. ŠTAMBERG collection), the museum of Wroclaw University (GÖPPERT'S collection) and the Czech Geological Survey in Prague, have yielded more than 30 biological species from the Olivětín Member. Seeds, fructifications and most of GÖPPERT's collection need to be revised.

Palynology of the Olivětín Member was recently published by BEK and OPLUŠTIL (2021), who compiled data of KAISEROVÁ-KALIBOVÁ (in TÁSLER et al. 1979). Palynology of the Polish part of the Intrasudetic Basin was published by JERZYKIEWICZ (1987) from the Stephanian and early Permian. The assemblage of the upper Anthracosia shale is approximately time eqivalent with the Bečkov Member in the Czech part of the Intrasudetic Basin.

2. MATERIAL AND METHODS

All the material came from the Janików locality, which is situated on the right side of the Božanov Creek at the Polish/Czech border (N: 50,545131°; E: 16,400102°). The specimens are now in the collections of the Czech Geological Survey, numbers ZŠ 856 – ZŠ 875. The studied outcrop belongs to the Ruprechtice Horizon, Olivětín Merber, Broumov Formation of the early Permian (Asselian) age.

All the fossils came from a bituminous mudstone layer, which has been divided into five layers, from top to bottom labelled A, B, C, D and E. The strata were poor in plant fossils, and the specimens were collected from fallen blocks of rocks the exact stratigraphical position of which was unknown. The rocks were split using chisels and a hammer, and each specimen was then determined, labelled and quantitatively evaluated. A total rock area of about 2 m^2 was used for collecting the fossils.

The botanical system according to CLEAL and THOMAS (1995) was used in this paper.

3. GEOLOGICAL SETTING

The Intrasudetic Basin is situated along the eastern margin of a suite of Late Palaeozoic Bohemian continental basins (Fig. 1) and covers an area of ca. 1800 km^2. It has an infill of up to 5 km of middle Viséan to Triassic strata with several hiatuses. The Viséan consists of a few kms of fluvial and alluvial-fan deposits with intercalated marine to deltaic intervals (TÁSLER et al., 1979,

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Figure 1. A map showing the position of the Intrasudetic Basin along the Czech-Polish border. The Janików locality is just at the border marked by an arrow.

BOSSOWSKI, 1995). They are overlain by Serpukhovian (early Namurian) fluvial and coal-rich deposits of the Wałbrzych Formation.

The depositional centre extended further to the south in the Bashkirian. The Žacléř Formation (late Bashkirian–early Moscovian; Yeadonian–Bolsovian) contains 60–80 coal seams in three members. The Kasimovian (Cantabrian to Saberian) is represented by the Odolov Formation that contains locally important coal seams of the Svatoňovice (Cantabrian) and Jívka (Saberian) formations (Table 1). The Saberian was defined by Wagner and Álvarez-Vázques (2010) as a lower part of the former Stephanian B. This concept was accepted by OPLUŠTIL et al. (2016) and this term is widely used in the literature, even if it was not formally approved.

The Stephanian/Permian Chvaleč Formation (the equivalent of the Krajanów Formation in the Polish part) is mostly composed of coal-barren fluvial red beds and contains only one thin coal seam in the Vernéřovice Member (Ludwikowice Fm.). Lacustrine horizons, a few tens of metres thick, with bituminous limestones and shales are rarely intercalated in the red beds (Bečkov Horizon – Krajanów Formation in Polish part). The overlying Broumov Formation (the equivalent of the Słupiec Formation in Polish part) contains the Nowa Ruda, Olivětín and Martínkovice members that correspond mainly to the Asselian (OPLUŠTIL et al. 2016). The Nowa Ruda Member ("Building Sandstones" in Polish part) is formed chiefly by thick complexes of rhyolite tuffs and tuffites, The Olivětín Member ("Walchia Shales" in the Polish part) contains up to several tens of metres thick mudstones with thin fossiliferous so-called "Walchia"shales and lacustrine bituminous shales and Ruprechtice and Otovice limestones. The Martínkovice Member also contains limestone horizons, but only animal fossils have been discovered. The Upper Permian Trutnov (represented by the Radków Formation in the Polish part) and the Bohuslavice formations are composed of red and brown mudstone and sandstone deposits, and the Middle Triassic Bohdašín Formation is represented mainly by white sandstones.

3.1. Description of the fossiliferous section

The Ruprechtice Limestone in its type area in the vicinity of Ruprechtice is a light grey, greenish, pinkish or mauve, heavy-bedded or slab-like limestone, passing into laminated marlstone in its upper part. Probably only *Autunia conferta* is known from this limestone in this area (RIEGER, 1966). The Ruprechtice Limestone also occurs further east, at Otovice, where TASLER et al. (1977) described it as a dark grey limestone with a bituminous development. RIEGER (1966) pointed out that Ruprechtice and Otovice limestones are very similar in the Otovice area and the de facto floras from those limestones are difficult to distinguish.

Table 1. Stratigraphic table of the youngest part of the Intrasudetic Basin. Adopted according to OPLUŠTIL et al. (2016) and ŠIMŮNEK (2019). Remark: Time intervals of the gaps between younger units are not known.

Global scale		Regional scale		Czech lithostratigraphic units		Polish lithostratigraphic units **		
				Formation	Member	Formation	Member	
Tri.	Middle			Bohdašín			"Red Sandstones"	
	Hiatus							246
Permian	?Lopingian?	Zechstein		Bohuslavice			Hiatus	
	Hiatus							
	Guadalupian	Rotliegend		Trutnov		Radków	Chełmsko Śląskie	
							Wambierzyce	
	Cisuralian			Hiatus				295
			Asselian*	Broumov	Martínkovice	Słupiec	"Walchia Shales"	
					Olivětín			
					Nowa Ruda		"Building Sandstones"	
				Chvaleč	Bečkov	Krajanów	"Upper Anthracosia Shales"	
Pennsylvanian	Gzhelian	Stephanian	C		Vernéřovice	Ludwikowice	"Lower Anthracosia Shales"	300
	Kasimovian		B	Hiatus				
			Saberian	Odolov	Jívka			
			Barruelian		"Žaltman Arkoses"			305

Key: Tri. - Triassic, * Stage of Global scale, Studied locality
** Correlation with Bohemian part according to SPUDIL in PEŠEK et al. (2001)

However, generally, all museum collections came from the Otovice Horizon because the classical localities "Otovice (Ottendorf)" were situated along the Stěnava river and Černý (Black) creek.

The Janików section consists essentially of tuffs and marlstones. The lowest part of the studied outcrop consists of dark, locally brown, silty tuff, altered by penetrating silica, possibly of volcanic origin. This rock also contains altered volcanic glass. The original structures are not traceable due to later alteration. The total thickness of this bed is unknown. The water level of the stream restricted excavation of the deeper part of the outcrop, thus only 1,5 metres is reported here.

The altered tuff is overlain by a dark, bituminous, calcareous shale, ca. 0.60 m thick, with plant fragments and a rich fish fauna; the fossil flora is presented in this article. The shale bed is overlain by 10 cm of mudstone, which is terminated by an uneven erosion surface. Above this erosion surface, there is a layer of light creamy rhyolitic tuff blocks, up to 1 m thick.

In the outcrop of the watercourse flowing into the Bożanowski stream, a higher part of the mudstone bed with tetrapod footprints clearly indicates that the water reservoir was shallowing.

4. SYSTEMATICS

4.1. Class Filicopsida (ferns)

Order Marattiales Engler et Prantl

Family ***Psaroniaceae*** UNGER

4.1.1. Genus *Cyathocarpus* WEISS, 1869

Representatives of Marattiales have been traditionally assigned to the fossil-genus *Pecopteris* Brongniart. However, CLEAL (2015) pointed out that the type species of *Pecopteris, Pecopteris pennaeformis*, belongs to the fossil-genus *Senftenbergia* SCHIMPER of the order Botryopteridales. So, as a genus cannot belong to more than one family and order, CLEAL (2015) assigned the other species traditionally accommodated in *Pecopteris* to various other fossil-genera. The following species should be transferred to the genus *Cyathocarpus* WEISS in the sense of MOSBRUGGER (1983).

4.1.1.1. *Cyathocarpus* cf. *densifolius* (GÖPPERT) comb. nov. (Pl. 1, Figs. i–k)

1864 *Cyatheithes densifolius* GÖPPERT, p. 120, pl. 17, figs. 1, 2.

1890 *Pecopteris (Asterotheca?) densifolia* (GÖPPERT) ZEILLER, p. 54–58, textfigs. 27, 28, pl. 7, fig. 3.

Description: Only three fragments of this species have been observed at the Janików locality. Although they are only small pinnule fragments, they have the typical pinnule shape and venation that determine them. The pinnules have rounded apices; the fragment on Pl. 1, Fig. k represents the apical part of a pinna of the last order with terminal pinnule and two small pinnules still basally fused. They are only 4 mm long and 3 mm wide. On the other hand, the specimen on Pl. 1, Fig. j represents the biggest pinnule, which might have been 11.5 mm long and 5 mm wide; the pinnule shown on Pl. 1 fig. i was probably of the same width. The venation is common for all samples, with lateral veins arising obliquely from the midrib and fork once or twice dichotomously.

Remarks: According to NĚMEJC (1948), *Cyatheithes densifolius* GÖPPERT, 1864, is conspecific with *Filicites oreopteridius* SCHLOTHEIM, 1804. However, *Filicites oreopteridius* was published before the starting point of 1820 and is considered as *nom. illegit.* and so, the correct species epithet should be *densifolius.* CLEAL (2015) argued that *Cyatheites* was a confused genus that had not been clearly typified and should be rejected. As the species belongs to the better-defined *Cyathocarpus*, we propose the new combination *Cyathocarpus densifolius.*

4.1.2. Genus *Lobatopteris* WAGNER, 1959.

4.1.2.1. *Lobatopteris* cf. *geinitzii* (GUTBIER) WAGNER (Fig. 5a, Pl. 1, Fig. h)

1864/1865 *Asterocarpus geinitzi* GUTBIER: GÖPPERT, p. 128–129, pl. 8, fig. 8.

1983 *Lobatopteris geinitzii* (von GUTBIER) emend. STERZEL) comb. nov., WAGNER. p. 138–146, pl. 1, figs. 1–4, pl. 3, figs. 1a, 2a, 10. pl. 4, figs. 3a, 10b, 11, 11a.

2009 *Lobatopteris geinitzii* (GUTBIER) WAGNER: BARTHEL, p. 50–51, Teil 3, figs. 99–102.

Description: Only a small questionable fragment has been discovered in layer C, representing part of a last order pinna with four pinnules (Pl. 1, Fig. h). The pinnules are 3.5–4 mm long and about 3 mm wide, and the apex is nearly rounded. A thin vein enters each pinnule and divides forming a "lobatopterid" vein pattern.

Remarks: This small fragment is compared with *Lobatopteris geinitzii* as figured by BARTHEL (2009, fig. 100b). *Lobatopteris geinitzii* was mentioned also by GÖPPERT (1864/1865) as *Asterocarpus geinitzi* from "Oelberg bei Braunau" (Olivětín u Broumova). NĚMEJC (1940) placed *Pecopteris crenulata* BRONGNIART as figured by POTONIÉ (1893) into his new species *Asterotheca thuringiaca*. BARTHEL (2009) synonymised both species with *Lobatopteris geinitzii.*

BARTHEL (1976) published similar specimens under the name *Pecopteris polypodioides* (PRESL in STERNBERG) NĚMEJC and compared his Permian material with Bohemian type material of *Pecopteris polypodioides* from the Asturian. *Pecopteris polypodioides* was transferred to *Lobatopteris* WAGNER by KNIGHT (1983) – *Lobatopteris polypodioides* (PRESL in STERNBERG) KNIGHT, 1983. NĚMEJC (1940) studied Asturian, late Stephanian and Permian specimens named as *Pecopteris polypodioides* and found out that the Stephanian and Permian ones have markedly smaller pinnules than the Asturian ones, even if their shape and venation was similar. BARTHEL (1980b) also named the Permian specimens as *Pecopteris polypodioides* (PRESL in STERNBERG) NĚMEJC, but later Barthel (2009) detrermined the Permian representatives to *Lobatopteris geinitzii* (von GUTBIER, emend. STERZEL) WAGNER.

4.1.2.2. *Lobatopteris* sp. nov. (Pl. 1, Fig. f, g)

?1927 *Pecopteris* nov. spec. LIPPS, p. 578, p. 28, fig. 2, 2a.

1990 *Pecopteris polypodioides* (STERNBERG): ŠIMŮNEK et al., p. 28–29, pl. 29, figs. 4 and 5.

Description: This species is relatively common in sub-layers B, C, D, E at the Janików locality. Only incomplete last order pinnae are preserved, up to 16 mm long and 4 mm wide (Pl. 1, Fig. g). The latter specimen has small, relatively wide pinnules, 1.5–2.2 mm long and 1.5–2 mm wide, of oval shape and attached to the rachis by their whole base. A smaller pinna (Pl. 1, Fig. f) is only 8 mm long and 3.5 mm wide, with pinnules about 1.5 mm long and 1 mm wide. The pinnule apex is always rounded. The venation is poorly visible; the midrib is not seen. It looks like a thin vein enters and forks into several veins in the pinnule.

Remarks: Similar specimens have been figured by BARTHEL (1976, e.g. pl. 16, fig. 10) under the name *Pecopteris polypodioides* from the Permian of the Döhlen Basin, Germany. The

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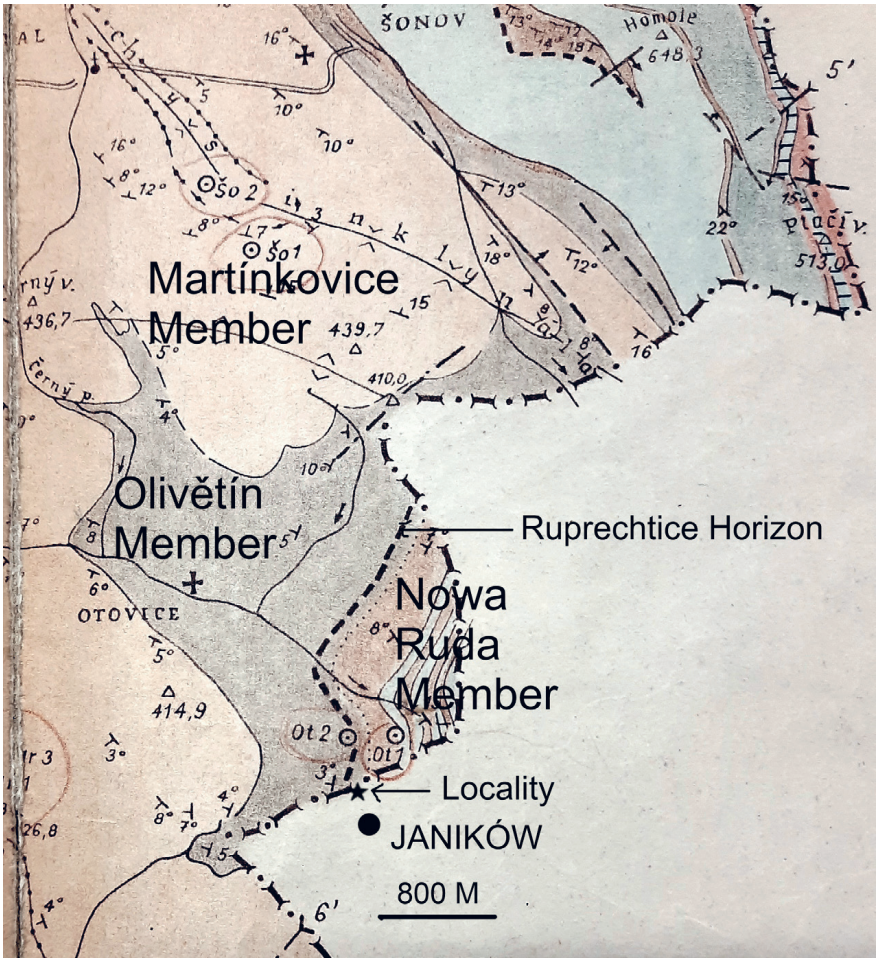

Figure 2. Detail of the geological map of the Broumov Permian with the Janików locality. (Orig. TÁSLER et al. (1966).

rich BARTHEL (1976) material shows the variability of the pinnules in different parts of the frond. Although of comparable size, *Lobatopteris* sp. has better individualised, non-lobed pinnules than the *Pecopteris polypodioides* documented by BARTHEL (1976), i.e., *Lobatopteris geinitzii.*

In our opinion, this *Lobatopteris* sp. is a new species comparable with *Pecopteris* nov. sp. of LIPPS (1927) and is conspecific with specimens from the Permian of the Krkonoše Piedmont Basin described by ŠIMŮNEK et al. (1990) as *Pecopteris polypodioides.*

4.2. Systematic position uncertain

4.2.1. *Sphenopteris* sp.

Several specimens have been classified as *Sphenopteris* sp. (Table 1). These specimens represent fragments of sphenopteroid pinnules but are not determinable to species.

4.3. Order Zygopteridales EMBERGER (Coenopteridales)

Family *Zygopteridaceae* P. BERTRAND ex B. SAHNI

4.3.1. Genus *Alloiopteris* H. POTONIÉ

4.3.1.1. *Alloiopteris* aff. *erosa* (GUTBIER) STERZEL (Fig. 5b, Pl. 1, Fig. a)

1978 *Alloiopteris erosa* (GUTBIER) STERZEL: BOERSMA, p. 58, pl. XI, figs. 1, 2.

2004 *Alloiopteris erosa* Gutbier: Galtier , p. 213, fig. 4, pl. 7, figs. 1–4,

Description: Only four specimens from Janików has been identified as *Alloiopteris* aff. *erosa*, all in sub-layer B. The most complete fragment is 19 mm long and 3 mm wide (Fig. 5b, Pl. 1, Fig. a) and is a last order pinna. The smaller fragments are as little as 7 mm long and 2.5 mm wide. The pinnules are small and partly fused (Fig. 5b). The pinnule margin is irregular with lobes, and thus it is gibbous (Fig. 5b, Pl. 1, Fig. a). The venation is not prominent and was probably rarely forked, although this is mostly not visible on the specimens.

Remarks: *Alloiopteris* is rarely found in deposits younger than Westphalian. BOERSMA (1978) mentioned the range of *Alloiopteris erosa* as being from the Asturian ("Westphalian D") to the Barruelian ("Stephanian A"). NĚMEJC (1958) mentioned *Alloiopteris* cf. *angustissima* (STERNBERG) from the Saberian ("Stephanian B") Radvanice coal seams. The first author collected *Alloiopteris* similar to *Alloiopteris erosa* before the closing of the Kateřina II coal mine in Radvanice, Intrasudetic Basin. GALTIER (2004) described *Alloiopteris erosa* from the Stephanian B as the youngest representative of this genus. Now, we have similar specimens in the Permian (Asselian) of the Intrasudetic Basin.

4.3.2. *Nemejcopteris* BARTHEL, 1968

4.3.2.1. *Nemejcopteris feminaeformis* (SCHLOTHEIM ex STERZEL) BARTHEL (Pl. 1, Figs. b, c)

1820 *Filicites feminaeformis* SCHLOTHEIM, p. 307.

1968 *Nemejcopteris feminaeformis* (SCHLOTHEIM) comb. nov.; BARTHEL, p. 733, pl. 1–4,

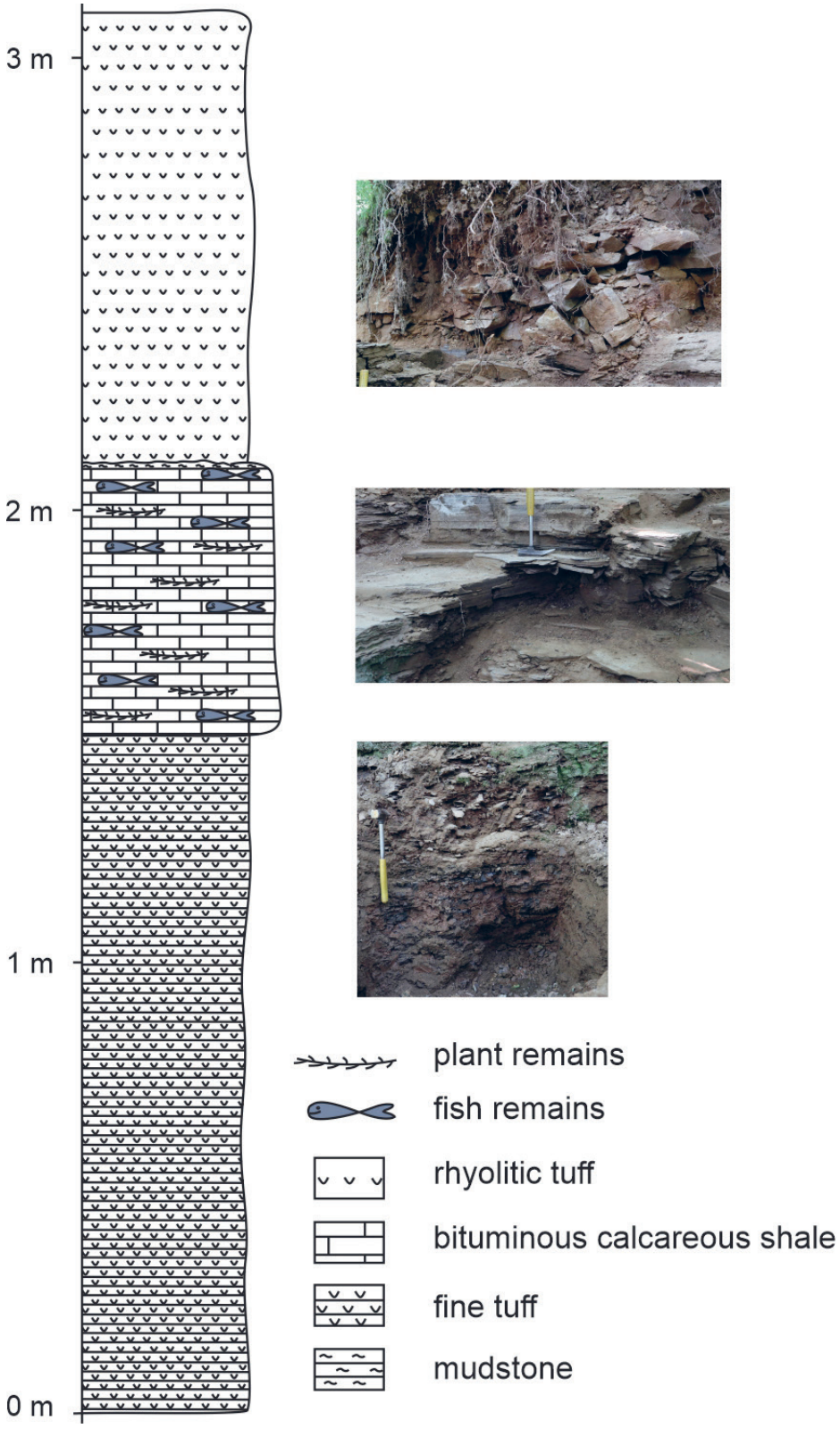

Figure 3. Section through the outcrop in Janików and images for comparison.

2016 *Nemejcopteris feminaeformis* (SCHLOTHEIM ex STERNBERG) BARTHEL; BARTHEL, p. 151, figs. 85–91, 92a.

Description: Only last order pinna fragments with two to 18 pinnules are preserved in lengths up to 20 mm. The pinnules are triangular with dentate margins, usually 4–7 mm long and 2–3 mm wide. The pinnules are basally fused. The venation is simple, pinnate. Straight lateral veins arise at sharp angles from the midrib and end in teeth on the margin.

Remark: This species is typical by its pinnule shape and is easily distinguished from other zygopterid species. In Central Bohemia, it is known mainly in Saberian (Stephanian B) deposits of the Mšec and Hředle Members of a lake or deltaic origin. It is a similar situation in Janików. *Nemejcopteris feminaeformis*

Figure 4. An image of the Janików section. Hammer is in the fossiliferous layer.

was studied in detail by Barthel (1968, 1976, 1980a, 2009, 2016). BARTHEL's *Nemejcopteris feminaeformis* specimens come from Germany, and they are of the same age as specimens from the Janików locality.

4.4. Order Filicales ENGLER et PRANTL

Family *Tedeleaceae* Eggert et T.N. TAYLOR (incl. *Senftenbergiaceae* REED)

4.4.1. Genus *Senftenbergia* CORDA.

4.4.1.1. *Senftenbergia* sp. (Pl. 1, Figs. d, e)

Description: *Senftenbergia* sp. is not common in the Janików locality in sub-layer C. The larger fragment is 17.5 mm long and 4.8 mm wide (Pl. 1, Fig. e). The pinnules are small, from 1 to 2.5 mm long and 1 to 2 mm wide. Their shape is triangular with crenulated margins and a nearly pointed apex. The second specimen (Pl. 1, Fig. d) is a small fragment of a bigger frond. The pinnules are 4 mm long, basally fused. The venation is rare; the veins usually obliquely grow from the midrib.

Remarks: Only small fragments have been found, and therefore, it is difficult to determine them. The most widespread species is *Senftenbergia plumosa.* Even if it was also mentioned from the Stephanian and Permian, it is most common in the Westphalian. Several similar species are known from the Permian: e.g., *Senftenbergia saxonica* BARTHEL (1976) and *Dactylotheca elaverica* (ZEILLER) BARTHEL. *Sphenopteris mathetii* ZEILLER (BARTHEL, 2009, fig. 156) is another similar species.

Pteridosperms

4.5. Order Callistophytales ROTHWELL

Family *Callistophytaceae* STIDD et J.W. HALL

4.5.1. Genus *Dicksoniites* SCHLOTHEIM ex STERNBERG.

4.5.1.1. *Dicksoniites* cf. *plukenetii* (SCHLOTHEIM ex STERNBERG) STERZEL (Pl. 1, Fig. l)

Description: Only tiny fragments of pinnae were found (Pl. 1, Fig. l). Most fragments are less than 1 cm long, but the pinnules are usually recognizable with a sphenopterid shape and sparse venation. This species is relatively common in the Janików locality in layers B, C, D and E.

Remarks: This species is classified as *Dicksoniites* cf. *plukenetii* due to its fragmentary preservation.

4.6. Order Trigonocarpales, (medullosaleans)

Family Trigonocarpaceae

4.6.1. Genus *Trigonocarpus* BRONGNIART

4.6.1.1. Trigonocarpus sp. (Pl. 2, Fig. b)

Description: The only representative of the Trigonocarpales (Medullosales) from the Janików locality is this seed *Trigonocarpus.* It is relatively large, 14.5 mm long and 10.5 mm wide, and typical of *Trigonocarpus* with three longitudinal ribs.

Remarks: BARTHEL (2009) described several 10–25 mm long seeds as *Trigonocarpus* sp. BARTHEL (2009) compared them with *Trigonocarpus noeggerathii* (STERNBERG) BRONGNIART; however, he did not use this name because of the diverse seed assemblage. *Trigonocarpus noeggerathii* has been figured, by POTONIÉ (1893, pl. 33, figs 7, 8) from the Permian of the Thüringian Forest, but the species name has probably been used for various biological species.

4.7. Order Peltaspermales TAYLOR

Family *Autuniaceae* DOWELD

4.7.1. Genus *Autunia* KRASSER

4.7.1.1. *Autunia conferta* (STERNBERG) KERP (Pl. 1, Fig. m.)

1864/1865 *Callipteris affinis* GÖPPERT: GÖPPERT, p. 104, pl. 13, figs. 1 and 2.

1980 *Callipteris conferta* (STERNBERG) BRONGNIART: BARTHEL et HAUBOLD, p. 49–105, figs. 1–11, pls. 1–15

1988 *Autunia conferta* (STERNBERG) KERP, p. 258–305, Pl. 1–25, Figs. 3–8.

Description: Only one pinnule fragment from layer C at the Janików locality has been found. This has a linguaeform pinnule shape, with a nearly rounded apex and lobate margin, 12 mm long and about 5 mm wide. A vein that divides several times enters each lobe from the midrib (Pl. 1, Fig. m).

Remarks: BARTHEL and HAUBOLD (1980) studied specimens of *Autunia conferta* in detail and distinguished many forms, including that described earlier by GÖPPERT as *Callipteris affinis* (GÖPPERT, 1864/1865, pl. 13, figs. 1 and 2) from Otovice (Ottendorf) from the Intrasudetic Basin. BARTHEL et HAUBOLD (1980) named this form as "*Callipteris conferta* ssp. 6 bl"

4.8. Class Pinopsida BURNETT

Order. Cordaitanthales MEYEN (Cordaitales SCOTT)

Family *Cordaitanthaceae* MEYEN (*Cordaitaceae* GRAND'EURY)

4.8.1. Genus: *Cordaites* UNGER

4.8.1.1. *Cordaites* sp. (Pl. 2, Fig. 1)

Description: Only three *Cordaites* fragments have been identified in the Janików locality (see Tab. 1). The biggest fragment is 170 mm long and 19 mm wide with nearly parallel margins. The sample from layer A is 32 mm long and 10 mm wide. Apex and bases are not preserved, and the venation itself is insufficient to determine *Cordaites* species. The bigger fragment has about 20 veins; the smaller fragment from layer A (Pl. 2, fig. 1) has approximately 25 veins per cm.

Remark: Cordaitaleans from the Otovice localities have been recently studied (ŠIMŮNEK, 2019). Also, LIPPS (1927) described *Cordaites principalis* (GERMAR) GEINITZ from the Permian of Unisław Śląski from the Intrasudetic Basin and mentioned 18–24 veins per cm and 3–4 sclerenchymatous bundles between each pair of veins. These characteristics correspond to

Table 2. Distribution of plant species in individual sub-layers in the Janików locality from the top to the base. The last column shows species where the exact position is unknown.

Species	Janików						Total
	A	B	C	D	E		
Cyathocarpus cf. *densifolius*		1			1	1	3
Lobatopteris cf. *geinitzii*			1				1
Lobatopteris sp. nov.		2	2	1	2	2	9
Sphenopteris sp.			1			3	4
Alloiopteris aff. *erosa*		3				1	4
Nemejcopteris feminaeformis		1			1	5	7
Senftenbergia sp.			1			1	2
Dicksoniites cf. *plukenetii*		1	1	1	3	3	9
Trigonocarpus sp.						1	1
Autunia conferta			1				1
Cordaites sp.	1		1			1	3
Cardiocarpus sp.			1			1	2
Seed						1	1
Plant axis			1	1		4	6
Total	1	8	10	3	7	24	53

the type of *Cordaites principalis* (GERMAR) GEINITZ (see ŠIMŮNEK, 2015) however, the absence of the leaf apex and base make it problematic to identify to species level. ŠIMŮNEK (2019) classified cordaitalean species from the Permian of the Intrasudetic Basin based on more complete specimens and assigned similar narrow leaves as *Cordaites* cf. *roesslerianus* GEINITZ. According to venation, the Janików specimen could belong to either *Cordaites principalis* or *C.* cf. *roesslerianus.*

4.8.2. Genus *Cardiocarpus* BRONGNIART

4.8.2.1. *Cardiocarpus* sp. (Pl. 2, Fig. c)

Description: This seed comes from layer C of the Janików locality. It is oval, slightly ovoid, 11 mm long, and 9 mm wide. The sclerotesta represents most of the seed body, sarcotesta being restricted to a narrow rim around the seed. A shallow, narrow groove runs from micropyle to chalaza.

Remarks: BARTHEL (2009) classified the Permian *Cardiocarpus* seeds as *Cardiocarpus gutbieri* GEINITZ with reference to POTONIÉ (1893). POTONIÉ (1893) figured several seeds (his pl. 31, figs 15–19) as *Cardiocarpus gutbieri,* however, these seeds are bigger than those from Janików – 15–30 mm long. LIPPS (1927) also mentioned *Cardiocarpus gutbieri* from Unisław Śląski, however, he did not mention their dimensions. GÖPPERT (1864/1865) mentioned several seed species from the surroundings of Broumov and Nowa Ruda; they require revision.

4.9. Plant axes

Description: These are the most abundant specimens from the Janików locality. They are up to 20 cm or more long, less than 1 cm to several cm wide. One, ca. 10 mm wide axis is distorted. These axes may be parts of rachises from creeping ferns or pteridosperms (*Alloiopteris, Nemejcopteris, Senftenbergia* or *Dicksoniites*).

5. DISCUSSION

Near Janików, the Ruprechtice Limestone is developed as a calcareous bituminous shale and yields a distinctive macroflora lacking conifers and only rare *Autunia conferta.* However, this assemblage is dominated by creeping and lianascent ferns including *Nemejcopteris feminaeformis* and tree ferns mentioned here *Lobatopteris* sp. nov. Table 2. shows that many species are new for the Permian of the Intrasudetic Basin: *Alloiopteris* aff. *erosa, Nemejcopteris feminaeformis* and *Cyathocarpus* cf. *densifolius.*

Alloiopteris aff. *erosa* is probably the youngest example of this genus known anywhere in the world. *Nemejcopteris feminaeformis* is known from the same age strata from Germany (BARTHEL, 2009, 2016) and in the Boskovice Basin in Moravia (ŠIMŮNEK & MARTÍNEK, 2009). *Cyathocarpus* cf. *densifolius* is also known from the same age strata in Germany. NĚMEJC (1940) described *Asterotheca thuringiaca* from the Broumov region, and according to BARTHEL (2009), it is conspecific with *Lobatopteris geinitzii. Senftenbergia* was not previously mentioned from the Permian of the Intrasudetic Basin, but a specimen similar to *Senftenbergia saxonica* is deposited in the National Museum in Prague. *Dicksoniites plukenetii* has not previously been mentioned from the Bohemian part of the Intrasudetic Basin but is recorded by LIPPS (1927) from Polish Unisław Śląski (Langwaltersdorf) in the same strata about 20 km NNW from Janików. So, nearly half of the assemblage is not typical for the Olivětín Member. The flora as a whole suggests a subhumid climate with representatives of different groups of ferns and pteridosperms.

The Janików plant assemblage is poor and fragmentary, with slightly over 50 specimens having been found within the space of a week. The flora is restricted to a 0.6 m thick calcareous bituminous mudstone (shale) (Table 1). This layer was divided into 5 sub-layers from top to base: A, B, C, D, E. Only a fragment *Cordaites* sp. has been found in sub-layer A. The other layers yielded more plant fragments; however, with so few specimens having been found, it is difficult to trace any clear trend in the distribution of the taxa. Only *Lobatopteris* sp. nov. and *Dicksoniites* cf. *plukenetii* are known from all sub-layers B–E. Nearly half of the samples have been found from rocks without knowing the exact location stratigraphically. Together with plant fossils, fish remains have also been found.

The black shales are considered to represent deep-water deposits. The small fragments (mostly less than 3 cm) indicate long-distance transport from the lakeshore, maybe several hundred

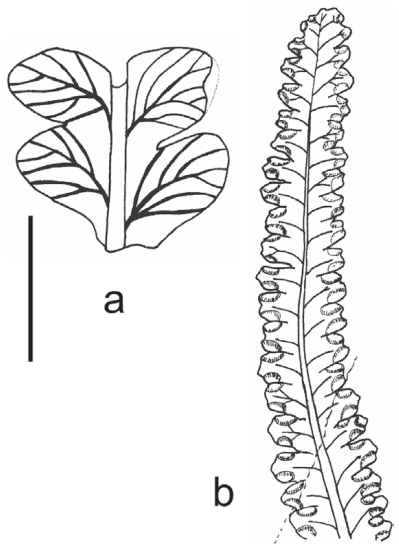

Figure 5. a – Venation diagram of *Lobatopteris* cf. *geinitzii*; b – Venation diagram of *Alloiopteris* cf. *erosa*. The shaded pinnule margins represent the gibbous (distorted) pinnule blade. Scale bar = 5 mm.

metres or more. The presence of fish and coprolites and an absence of mud cracks and ripples indicate relatively deep-water conditions from the beginning of sedimentation. The plant remains include tiny fragments of pinnules and pinnae, mostly of arborescent and creeping ferns and pteridosperms, probably from coastal vegetation. The seed plants probably grew behind this barrier of coastal vegetation, but their existence is only indicated by *Cardiocarpus* and *Trigonocarpus* seeds. During the sedimentation of the lake deposits, the climate was probably subhumid (BASHFORTH et al., 2021).

6. CONCLUSION

The hygrophilous to mesophilous plant assemblage from the Janików locality comprises arborescent and lianascent ferns and pteridosperms probably representing coastal vegetation of the Ruprechtice lake. The climate in this interval of the Asselian was subhumid. *Cyathocarpus* cf. *densifolius* is a new species record for the Intrasudetic Basin. *Nemejcopteris feminaeformis* and *Alloiopteris* aff. *erosa* have their last appearance data here. The remains of the fossil-genera *Sphenopteris, Lobatopteris* and *Senftenbergia* could not be classified to species. Pteridosperms were represented by *Dicksoniites* cf. *plukenetii* and *Autunia conferta.* A seed *Trigonocarpus* sp. indicates medullosan pteridosperms growing behind the barrier of coastal vegetation. Cordaitaleans were presented by *Cordaites* sp. and *Cardiocarpus* sp. Although arid climates tended to prevail in this region during the Asselian, the assemblage reported here shows that there could also be intervals with subhumid climates.

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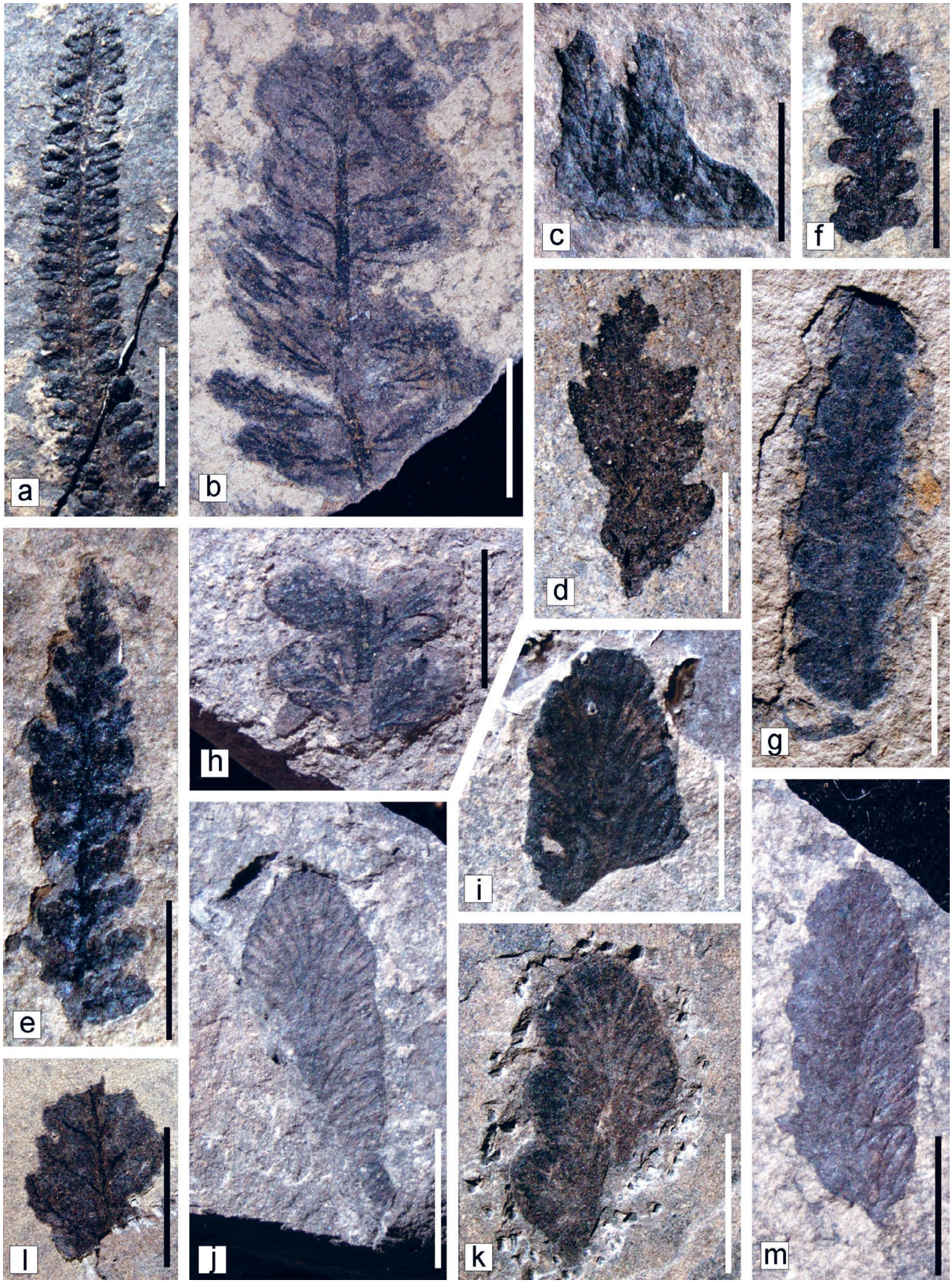

Plate 1

Flora from the Janików, Božanovský Creek, locality. B, C, D and E designate the sub-layer from which the specimen originated; (-) means the sub-layer is unknown. Specimens from the Collections of the Czech Geological Survey, Prague. All figures scale bar = 5 mm. **a** – *Alloiopteris* cf. *erosa,* B, inv. No.: ZŠ 856., **b** and **c** – *Nemejcopteris feminaeformis,* B and (-), inv. Nos. ZŠ 857 and ZŠ 858. **d** and **e** – *Senftenbergia* sp., C – (-), inv. Nos. ZŠ 859 and ZŠ 860., **f** and **g** – *Lobatopteris* sp. nov., C – B, inv. Nos. ZŠ 861 and ZŠ 862., **h** – *Lobatopteris* cf. *geinitzii,* C, inv. No.: ZŠ 863, **i** – **k** – *Cyathocarpus* cf. *densifolius,* C–(-)–E, inv. Nos. ZŠ 864, ZŠ 865 and ZŠ 866., **l** – *Dicksoniites* cf. *plukenetii,* D, inv. No.: ZŠ 867., **m** – *Autunia* cf. *conferta,* C, inv. No.: ZŠ 868.

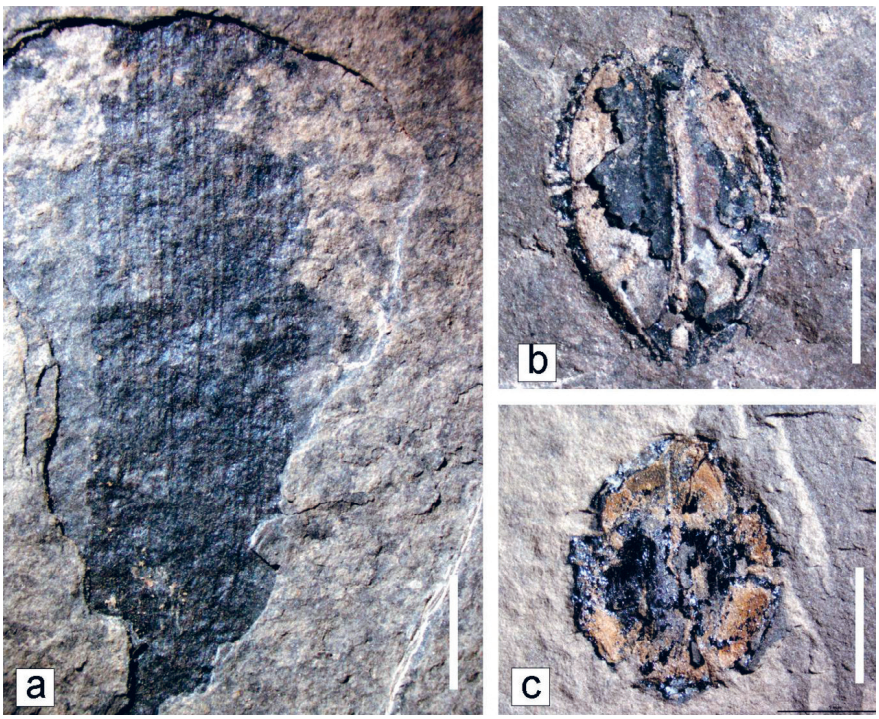

Plate 2

Flora from the Janików, Božanovský Creek, locality A and C designate the sub-layer from which specimen originated; (-) means the sub-layer is unknown. Specimens from the Collections of the Czech Geological Survey, Prague. All figures scale bar = 5 mm. **a** – *Cordaites* sp., A, inv. No.: ZŠ 868., **b** – *Trigonocarpus* sp., (-), inv. No.: ZŠ 870., **c** – *Cardiocarpus* sp., C, inv. No.: ZŠ 871.