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 Olívětín Member, Broumov Formation. The plant fossils were usually fragmentary, and the following taxa were determined: Alloiopteris aff. eosa, Nemjecopteris feminaformis, Senftenbergia sp., Lobatopteris sp., Sphenopteris sp., Cyathocarpus cf. densifolius, Lobatopteris cf. geinitzii, Lobatopteris nov. sp., Dicksonites 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 Taeiopteris 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. NÉMEJC (1953) mentioned a list of 10 species from the localities Olívětín, Otovice and Ruprechtice, (Broumov Formation, Olívětín Member). Interest in the Intrasudetic Basin increased in the 1960s due to geological mapping, and RIEGER (1966) listed 22 species from the Olívětín Member (in TÁSLER et al., 1966). SETLIK in TÁSLER et al. (1979) gave essentially the same list as in NÉMEJC (1953). BORS (1988) was the last researcher who studied the Olívětín 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 Olívětín Member. Seeds, fructifications and most of GÖPPERT’s collection need to be revised.

Palynology of the Olívětín 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 equivalent 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 Božanów 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, Olívětín Member, 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 m² 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 km². 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,
BOSSOWSKI, 1995). They are overlain by Serpukhovian (early Namurian) fluvial and coal-rich deposits of the Walbrzych 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 Saberian (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 Verněřovice 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 Ślupiec Formation in Polish part) contains the Nowa Ruda, Olívětín and Martiníkovice 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 Olívětín 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 Martiníkovice Member also contains limestone horizons, but only animal fossils have been discovered. The Upper Permian Trnúť (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.

<table>
<thead>
<tr>
<th>Global scale</th>
<th>Regional scale</th>
<th>Czech lithostratigraphic units</th>
<th>Polish lithostratigraphic units **</th>
</tr>
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<tbody>
<tr>
<td>Tri.</td>
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<td>Bohdašín</td>
<td>&quot;Red Sandstones&quot;</td>
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<td>Hiatus</td>
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<td>?Lopingian?</td>
<td>Zechstein</td>
<td>Bohuslavice</td>
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<td>Guadalupian</td>
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<td>Chelmnsko Śląskie</td>
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<td>Cisuralian</td>
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<td>Permian</td>
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<td>Broumov</td>
<td>&quot;Walchia Shales&quot;</td>
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<td>Olívětín</td>
<td>&quot;Building Sandstones&quot;</td>
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<td>Nowa Ruda</td>
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<td>Chvaleč</td>
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<td>Verněřovice</td>
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<td>Guadalupian</td>
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<td>Hiatus</td>
<td>&quot;Lower Anthracosia Shales&quot;</td>
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<td>Zaltman Arkoses</td>
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</table>

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 Otvovice Horizon because the classical localities “Otvovice (Ottendorf)” were situated along the Stěnava river and Černý (Black) creek.

The Janików section consists essentially of tufts and marlstones. The lowest part of the studied outcrop consists of dark, locally brown, siltty, 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 Janików section consisting essentially of tuffs and marlstones. The lowest part of the studied outcrop consists of dark, locally brown, siltty, 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 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 was situated along the Stěnava river and Černý (Black) creek.

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 pennaformis, belongs to the fossil-genus Senftenbergia SCHIMPER of the order Botryopteridales. So, as a genus, cannot not 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. 1–k)

1864 Cyatheithes densifolius GÖPPERT, p. 120, pl. 17, figs. 1, 2.
1890 Pecopteris (Asterotheca?) densifolia (GÖPPERT) ZIELLER, 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 pinnule 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 Cyatheithes 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.


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

1864/1865 Asterocarpus geinitzii 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.

Description: Only a small questionable fragment has been discovered in layer C, representing part of a last order pinnule 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 BARTHÉL (2009, fig. 100b). Lobatopteris geinitzii was mentioned also by GÖPPERT (1864/1865) as Asterocarpus geinitzii from “Oelberg bei Braunau” (Olivětín u Broumov). NĚMEJC (1940) placed Pecopteris crenulata BRONGNIART as figured by POTONIÉ (1893) into his new species Asterotheca thuringiaca. BARTHÉL (2009) synonymised both species with Lobatopteris geinitzii.

BARTHÉL (1976) published similar specimens under the name Pecopteris polyoidoiodes (PRESL in STERNBERG) NĚMEJC and compared his Permian material with Bohemian type material of Pecopteris polyoidoiodes from the Asturian. Pecopteris polyoidoiodes was transferred to Lobatopteris WAGNER by KNIGHT (1983) – Lobatopteris polyoidoiodes (PRESL in STERNBERG) KNIGHT, 1983. NĚMEJC (1940) studied Asturian, late Stephanian and Permian specimens named as Pecopteris polyoidoiodes 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. BARTHÉL (1980b) also named the Permian specimens as Pecopteris polyoidoiodes (PRESL in STERNBERG) NĚMEJC, but later Barthel (2009) determined 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 polyoidoiodes (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 pinnule (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 BARTHÉL (1976, e.g. pl. 16, fig. 10) under the name Pecopteris polyoidoiodes from the Permian of the Döhlen Basin, Germany.
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 polypodioïdes 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 polypodioïdes.

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 Katerina 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,
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, pin-nate. 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*
was studied in detail by Barthel (1968, 1976, 1980a, 2009, 2016). BARTHEL’s *Nemecopteris 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 elavérica* (ZEILLER) BARTHEL. *Sphenopteris mathetti* 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. *plukanetti* (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. *plukanetti* due to its fragmentary preservation.

### 4.6. Order Trigonocarpales, (medullosales) 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 Thüringer 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


Description: Only one pinnule fragment from layer C at the Janików locality has been found. This has a linguiform 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. l)**

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. l) has approximately 25 veins per cm.

Remark: Cordaitales 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.

<table>
<thead>
<tr>
<th>Species</th>
<th>Janików</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A  B  C  D  E</td>
<td></td>
</tr>
<tr>
<td>Cyathocarpus cf. densifolius</td>
<td>1  1  1  1  3</td>
<td></td>
</tr>
<tr>
<td>Lobatopteris cf. geinitzii</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lobatopteris sp. nov.</td>
<td>2  2  1  2  2</td>
<td>9</td>
</tr>
<tr>
<td>Sphenopteris sp.</td>
<td>1</td>
<td>3  4</td>
</tr>
<tr>
<td>Alloiopteris aff. erosa</td>
<td>3  1  4</td>
<td></td>
</tr>
<tr>
<td>Nemejcopteris feminaeformis</td>
<td>1  1  5  7</td>
<td></td>
</tr>
<tr>
<td>Senftenbergia sp.</td>
<td>1  1  2</td>
<td></td>
</tr>
<tr>
<td>Dicksonites cf. plukenetii</td>
<td>1  1  3  3</td>
<td>9</td>
</tr>
<tr>
<td>Trigonocarpus sp.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Autunia conferta</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cordaites sp.</td>
<td>1  1  1  2</td>
<td></td>
</tr>
<tr>
<td>Cardioxylon sp.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td>1  1  1</td>
<td></td>
</tr>
<tr>
<td>Plant axis</td>
<td>1  1  4  6</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1  8  10 3  7</td>
<td>24  53</td>
</tr>
</tbody>
</table>

the type of *Cordaites principalis* (GEMMAR) 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 *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, 1 cm 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: BARTHREL (2009) classified the Permian Cardiocarpus seeds as *Cardiocarpus gutbieri* GEINITZ with reference to POTONIE (1893). POTONIE (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 Dicksonites).

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 cf. 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 (SIMŮNEK & 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 BARTHHEL (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 saxonia* is deposited in the National Museum in Prague. *Dicksonites 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 Olivetin 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 0.3 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 Dicksonites 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
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 Janíkův 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. *Cysthidocarpus cf. densifolius* is a new species record for the Intrasudetic Basin. *Nemeciptopteris feminaeformis* and *Alloiptopteris aff. erosa* have their last appearance data here. The remains of the fossil-genera *Sphenopteris*, *Lobatoipteris* and *Senftenberga* could not be classified to species. Pteridosperms were represented by *Dicksonites cf. plukennetti* and *Antuna conferta*. A seed *Trigonocarpus* sp. indicates medulosan 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 2
Flora from the Janików, Bożanovski 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.