Paleontological Journal, Vol. 38, No. 4, 2004, pp. 458–464. Translated from Paleontologicheskii Zhurnal, No. 4, 2004, pp. 104–109.

Late Viséan Lyginopteridophytes from the Vicinity of the Town of Borovichi (Novgorod Region): 2. Lyginopteridales and Medullosales

O. A. Orlova* and S. M. Snigirevsky**

**Faculty of Geology, Moscow State University, Leninskie gory, Moscow, 119992 Russia*
e-mail: oorlova@geol.msu.ru
***St. Petersburg State University, Universitetskaya nab. 7/9, St. Petersburg, 199164 Russia*
Received June 6, 2002

Abstract—Five lyginopteridalean species of the genera *Rhodeopteridium* (Zimmermann) Purkynová and *Sphenopteris* Brongniart and one species of *Rhynchogonium* Heer (Medullosales=Trigonocarpales) are reported from the vicinity of the town of Borovichi (Upper Viséan deposits) for the first time. *Rhodeopteridium goeppertii* (Ettingshausen) O. Orlova et S. Snigirevsky comb. nov. is proposed. The study has revealed a rich preridospermous assemblage that characterizes the Early Carboniferous flora of the northwest of the Moscow Syneclise.

Key words: fernlike plants, cupule, morphology, Central Russia, Upper Viséan.

INTRODUCTION

The article continues our study of the Late Viséan lyginopteridophytes of the Novgorod region. The first part of the study concerned members of Calamopityales, among which the following six species were revealed: *Sphenopteridium pachyrrhachis* (Goepp.) Potonié, *S. jurinae* O. Orl. et S. Snig., *S. bifidum* (L. et H.) Benson, *S. gaebleri* Gothan, *Adiantites antiquus* (Ett.) Stur, and *A. machanekii* Stur. (Orlova and Snigirevsky, 2003). In central Russia, these species are known only from the Upper Viséan deposits of the Novgorod region (near the town of Borovichi), where we conducted field trips and collected fossil plants for more than 15 years. Remains of Late Viséan Calamopityales were found in two localities near the Porog Vittsa Rapids (Snigirevsky, 1994), 6 km upstream from the town of Borovichi (58°21′ N, 33°57′ E), on the left (Porog Vittsa 1) and right (Porog Vittsa 2) banks of the Msta River, respectively. The fossils are confined to terrigeneous sandy-silty interbeds. Sedimentologically, the interbeds correlate with both the Putlino and Jogla formations of the Upper Viséan (*Resolutions*..., 1990).

The present article describes Late Viséan plants of the orders Lyginopteridales and Medullosales (=Trigonocarpales). The fossils came from sandy-silty sediments of the locality of Porog Vittsa 2 (right bank of the Msta River). Among members of Lyginopteridales, five species of the genera *Sphenopteris* Brongniart and *Rhodeopteridium* (Zimmermann) Purkynová were reported. A new combination, *R. goeppertii* (Ett.) O. Orl. et S. Snig. comb. nov., is proposed for the latter genus. The species that are presently included in the genus *Rhodeopteridium* were long considered members of *Rhodea* Presl. However, *Rhodea* Presl is an invalid synonym of *Rhodea* Roth and a younger homonym of *Rhodea* Endlicher, which is why Zimmermann (1959) introduced the genus *Rhodeopteridium*. Unfortunately, *Rhodeopteridium* was invalidly published according to the International Code of Botanical Nomenclature, article 37.1 (*International*..., 1994; Kvaček and Straková, 1997, p. 22). Purkynová (1970, pp. 175–176) proposed *R. stachei* (Stur) Purkynová from the Lower Namurian of eastern Europe as a type species and, thus, made the generic name *Rhodeopteridium* valid. Consequently, *Rhodea goeppertii* (Ett.) Stur is transmitted from *Rhodea* to *Rhodeopteridium*, thus constituting a new combination, *Rhodeopteridium goeppertii* (Ett.) O. Orl. et S. Snig. comb. nov.

Here, we describe two species of *Sphenopteris*, *S. distans* Sternb., which is better known as *S. bermudensiformis* (Schloth.) Zeiller (see synonymy), and *S. foliolata* Stur. The correct name of the former species is cited much more rarely than its invalid synonym. According to article 13.1.(f) of the International Code of Botanical Nomenclature (1994), the date of publication of a paper by Sternberg (1820–1838)—December 31, 1820—is considered the initial date of valid publication of the fossil plant taxa. As the paper by Schlotheim (1820) appeared before the initial date, all descriptions of fossil plants from this work, including *Filicites bermudensiformis* Schloth. (Schlotheim, 1820, p. 409, pl. XXI, fig. 2), are invalid. *Sphenopteris foliolata* is assigned to *Eusphenopteris* as *E. foliolata* (Stur) van Amerom in some papers. The generic name

Eusphenopteris is used for the fronds of lyginopteridophytes that are related to the male fructifications of *Telangiopsis* Eggert et Taylor and female fructifications of *Calymmatotheca* Stur (van Amerom, 1975, p. 31). For the fragmentary material under description, which is represented by incomplete ultimate pinnae, the formal genus *Sphenopteris* seems to be the most appropriate.

The most interesting plant fossil under study is a seed cupule of the lyginopteridophyte *Rhynchogonium sulcatum* (L. et H.) Zal. (Medullosales=Trigonocarpales). We suggest that it is precisely the cupule that might have contained the seeds described by Zalessky (1905) nearly a century ago as *Boroviczia karpinskii* Zal. Zalessky's collection was long believed to be lost. It was not until 2000 that we found it among the collections of the Geological Institute of the Russian Academy of Sciences (Laboratory of Paleofloristics), where the holotype of *B. karpinskii* (type species of *Boroviczia*) is currently housed.

Members of the Lyginopteridales (*Sphenopteris* and *Rhodeopteridium*) and Medullosales (*Cardiopteridium* Nath.) are also known from Upper Viséan deposits in the southern Moscow Syneclise. However, they come from slightly older beds (Tulian Regional Substage) and are represented by different species: *Sphenopteris dicksonioides* (Goepp.) Weiss, *Sphenopteris stangeri* (Stur) Gothan, *Rhodeopteridium* sp., and *Cardiopteridium dobrovii* Zal. emend. O. Orl. (Orlova, 2002). Lyginopteridales are common in the Upper Viséan of Eurasia, Spitsbergen, and North America.

Thus, the Putlino and Jogla formations in the localities of Porog Vittsa 1 and 2 near the town of Borovichi (Novgorod region) contain the following lyginopteridophytes: *Sphenopteridium pachyrrhachis, S. jurinae, S. bifidum, S. gaebleri, Adiantites antiquus, A. machanekii, Adiantites* sp., *Rhodeopteridium hochstetteri* (Stur) Purkynová, *R. goeppertii* (Ett.) O. Orl. et S. Snig., comb. nov., *R. tenue* (Gothan) Purkynová, *Sphenopteris distans, S. foliolata, Sphenopteris* sp., *Telangiopsis* sp., and *Rhynchogonium sulcatum.* This list includes data on Calamopityales (Orlova and Snigirevsky, 2003) and taxa described in open nomenclature. Only two lyginopteridophyte species have been found in both of these localities, whereas all the others are known solely from Porog Vittsa 2. *Boroviczia karpinskii* was described by Zalessky from the left bank of the Msta River (Porog Vittsa 1).

MATERIAL

The fossil plants being studied are currently housed at the Paleontological Museum (Department of Paleontology) of St. Petersburg State University (collection PM SPGU, no. 24) and at the Department of Paleontology of the Faculty of Geology of Moscow State University (collection GF MGU, no. 289).

SYSTEMATIC PALEOBOTANY

DIVISION LYGINOPTERIDOPHYTA

CLASS LYGINOPTERIDOPSIDA

SUBCLASS LYGINOPTERIDIDAE

Order Lyginopteridales

Family Lyginopteridaceae Potonié, 1902

Genus *Rhodeopteridium* (Zimmermann) Purkynová, 1970

***Rhodeopteridium hochstetteri* (Stur) Purkynová, 1970**

Plate 10, fig. 1

Rhodea hochstetteri: Stur, 1875, p. 35, pl. VIII, fig. 2; Patteisky, 1929, p. 118, pl. 7, fig. 7; Tschirkova, 1934, p. 525, text-fig. 3; Novik, 1952, p. 278, pl. XLV, figs. 5–7.

Rhodea cf. *hochstetteri*: Lutz, 1933, p. 150, pl. XIX, fig. 23.

Rhodeopteridium hochstetteri: Purkynová, 1970, p. 176.

Description. The incomplete penultimate pinna is 44 mm long. The rachis is thin (1.5 mm wide), smooth, and slightly curved, with a median longitudinal groove. The pinnae of the last order are seven in number, alternate, arranged at an angle of 15°–25°, and spaced no more than 14 mm apart. They are linear to rhomboidal and up to 12 mm long. The ultimate rachis is thin (0.8 mm wide), smooth, and bears three or four alternating pinnules of linear to lanceolate outline. The pinnules vary from 4 to 6 mm in length and from 2 to 4 mm in width and are attached to the rachis at a very acute angle (10°). They are spaced no more than 2 mm apart and are divided into two or three segments at the apices. The venation is distinct: one vein comes from the solitary midvein of the rachis into each pinnule.

Comparison. The Early Carboniferous species *Rhodeopteridium machanekii* (Ett.) Purkynová (Kidston, 1923) shows the closest similarity to *R. hochstetteri* in the morphology of the ultimate pinna and in the shape and dimensions of the pinnules, but differs from the latter species in having narrower lanceolate pinnules and a smaller angle of the attachment of the ultimate pinnae to the rachis.

Occurrence. Tournaisian–Viséan of Europe and the Ural Mountains: Tournaisian of Germany and Ukraine (Donetsk Region), Viséan of France, Great Britain, the Czech Republic (Upper Viséan), Poland, and Russia (Lower Viséan of the Chelyabinsk region and Upper Viséan of the Novgorod region, the Putlino and Jogla formations).

Material. One penultimate pinna.

***Rhodeopteridium goeppertii* (Ettingshausen) O. Orlova et S. Snigirevsky, comb. nov.**

Plate 10, fig. 2

Trichomanites goepperti: Ettingshausen, 1865, p. 101, text-figs. 10, 11.

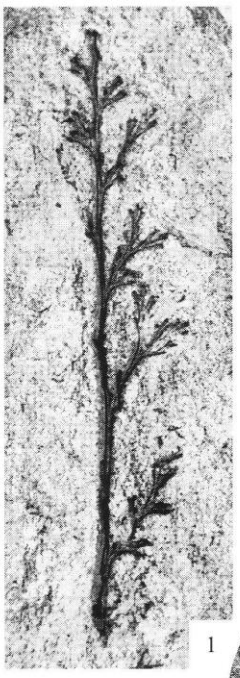
Sphenopteris (Trichomanites) goepperti: Schimper, 1869, p. 412.

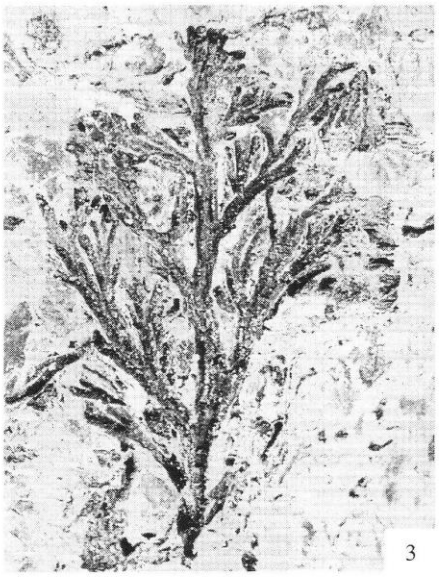
Rhodea goepperti: Stur, 1875, p. 41, pl. XI, figs. 3–7; Kidston, 1923, p. 233, pl. LVII, figs. 1, 1a; Lutz, 1933, p. 149, pl. XIX, fig. 19.

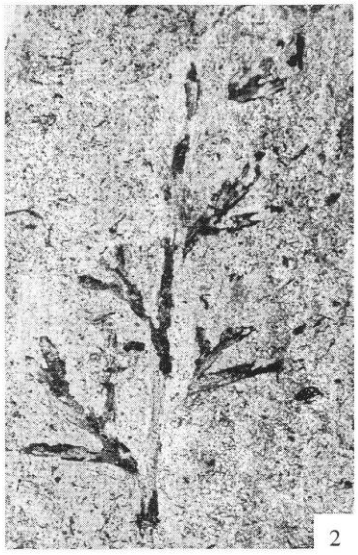
Alloiopteris (Trichomanites, Rhodea) goepperti: Zimmermann, 1956, p. 163, pl. XXVII, figs. 2, 3.

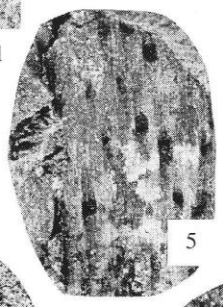
Alloiopteris goepperti: Purkynová, 1970, p. 183, pl. 22, figs. 2, 2a; 1985, p. 54, pl. VII, figs. 1, 2, 2a.

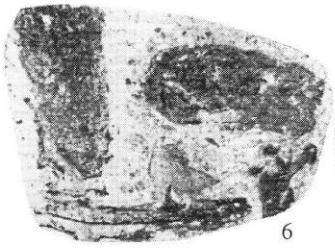
Plate 10


1

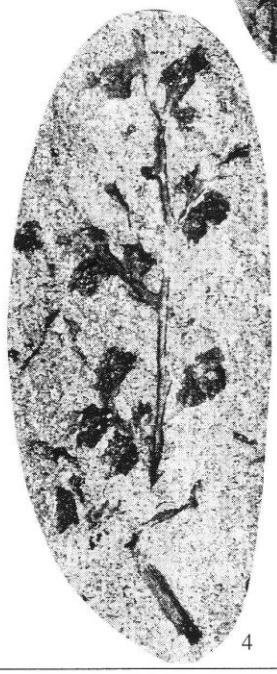

3

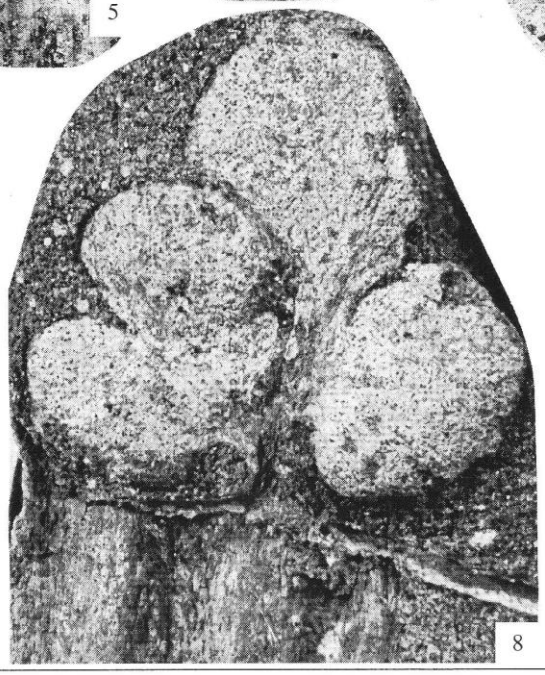

2


5


6


7


4


8


9

Lectotype. The specimen was shown by Ettingshausen (1865) in text-fig. 10 [designated here] and is currently housed at the Museum of Natural History of the Polytechnic Institute in Vienna (Austria); the collection number is not given. The specimen came from the vicinity of Kunzendorf (Poland), Lower Carboniferous, Kulm slates.

Description. The fragments of ultimate pinnae are up to 18 mm long and 11 mm wide. The rachis is thin, up to 0.8 mm wide, straight to slightly curved, smooth with a narrow longitudinal groove, and bears alternating pinnules. The pinnules are attached to the rachis at an angle of 45°, spaced 2.5–3 mm apart, and do not contact each other. They are small, dissected, and gradually diminish from the base toward the apex of the pinna. The largest pinnules reach 7 mm in length and 5 mm in width, whereas the smallest are less than 4 mm long and 2 mm wide. The pinnules dichotomize two or three times to form segments, which are linear to lanceolate, up to 3 mm long, and approximately 0.5 mm wide. The segments of a lower pinnule outnumber those of an upper pinnule (no more than five and three, respectively). The venation is poorly defined: one vein comes from the solitary midvein of the rachis into each pinnule and, subsequently, dichotomizes to enter each segment of the pinnule.

Comparison. The Early Carboniferous (Namurian A) species *Rhodeopteridium flabellatum* (Brongn.) Purkynová (Purkynová, 1970) closely resembles *R. goeppertii* in the pinnule outline, especially when the pinnule blade is preserved as thin fibrous segments. *R. goeppertii* differs from *R. flabellatum* in lacking punctuate sculpture on the rachises of the first and second orders. In addition, the pinnules of *R. goeppertii* are larger (up to 7 mm) than those of *R. flabellatum* (2–3 mm).

Occurrence. Tournaisian–Viséan of Europe: Tournaisian of Germany; Viséan of Great Britain, France, and Poland; and Upper Viséan of the Czech Republic and Russia (Putlino and Jogla formations of the Novgorod region).

Material. Six impressions of fragmentary ultimate pinnae.

***Rhodeopteridium tenue* (Gothan) Purkynová, 1970**

Plate 10, fig. 3

Rhodea tenuis: Gothan, 1913, p. 15, pl. 2, fig. 2; pl. 3, figs. 1–3; Kidston, 1923, p. 229, pl. LIX, fig. 7; pl. LXI, fig. 2; Walton, 1931, pp. 360–361, pl. 24, figs. 13–15.

Rhodeopteridium tenuis: Kotasowa, 1968, p. 52, pl. XXV, figs. 1 and 6.

Rhodeopteridium tenue: Purkynová, 1970, p. 177, pl. 18, figs. 1–2a.

Lectotype. The specimen was presented by Gothan (1913) in pl. 2, fig. 2 [designated here]. It is supposedly housed at the Royal Prussian Geological Museum of Berlin (collection SB') and was collected near the town of Rybnik (Poland), Lower Carboniferous, Ostrava–Silesian beds.

Description. The penultimate pinnae are up to 22 mm long. Their rachises are slightly curved, 0.8 mm wide, and bear ultimate pinnae, which are up to 10 mm long, attached to the rachis alternately at an angle of 15°–20°, spaced up to 3 mm apart, and contact one another. The ultimate rachis is thin (no more than 0.5 mm wide), curved, and bears two or three alternating pairs of tightly spaced and curved pinnules. The pinnules are subrhomboidal at the pinna base and wedge-shaped in the middle and apical regions of the pinna. Lower pinnules usually have four alternating lobes, which are occasionally missing. Lower lobes include two or three very narrow segments, and the upper lobes dichotomize. The terminal pinnules (up to 4 mm long) usually dichotomize up to three times. The apices of the segments are rounded. The venation is poorly preserved: each pinnule possesses one vein, which comes from the solitary midvein of the rachis.

Comparison. The Early Carboniferous species *Rhodeopteridium knoppianum* (Patt.) Remy (Kidston, 1923) is most closely related to *R. tenue* in pinna morphology. *R. tenue* differs from *R. knoppianum* in having more dissected, curved, and tightly spaced pinnules, whereas *R. knoppianum* has nearly straight, noncontacting pinnules that dichotomize into a smaller number of segments.

Remarks. The pinnae of *Rhodeopteridium tenue* (Novgorod region) were fossilized on an aggregation of shells of ostracods, which are too poorly preserved to be determined.

Occurrence. Upper Viséan–Serpukhovian of Europe: Upper Viséan of Great Britain and Russia (Put-

Explanation of Plate 10

Fig. 1. *Rhodeopteridium hochstetteri* (Stur) Purkynová, PM SPGU, no. 24/6-1, penultimate pinna, ×2.

Fig. 2. *Rhodeopteridium goeppertii* (Ett.) O. Orl. et S. Snig., comb. nov., PM SPGU, no. 24/7, incomplete ultimate pinna, ×4.

Fig. 3. *Rhodeopteridium tenue* (Gothan) Purkynová, PM SPGU, no. 24/12, fragmentary frond, ×4.

Figs. 4–7. *Sphenopteris distans* Sternb.: (4) PM SPGU, no. 24/8-1, ultimate pinna, ×4; (5, 6) PM SPGU, no. 24/10; (5) the sculpture of the rachis, ×3; (6) detached cupules, ×4; (7) MGU, no. 289/75, incomplete ultimate pinna, ×4.

Fig. 8. *Sphenopteris foliolata* Stur, PM SPGU, no. 24/11, a pinnule attached to the rachis, ×6.

Fig. 9. *Rhynchogonium sulcatum* (L. et H.) Zal., PM SPGU, no. 24/1, general view of the cupule, ×2.

Novgorod Region, right bank of the Msta River, Porog Vittsa-2 locality; Lower Carboniferous, Upper Viséan, Putlino and Jogla formations.

lino and Jogla formations, Novgorod region) and Serpukhovian (=Namurian) of Germany and the Czech Republic.

Material. Two specimens representing an impression and counterpart of a penultimate pinna.

Genus *Sphenopteris* Brongniart, 1822

Sphenopteris distans Sternberg, 1825

Plate 10, figs. 4–7

Sphenopteris distans: Sternberg, 1825, p. XVI; Brongniart, 1828, p. 198, pl. 54, figs. 3a and 3b; Goeppert, 1841, p. 68, pl. XI, fig. 1; Stur, 1875, p. 23, pl. 6, figs. 2–5; Weiss, 1881, p. 11, text-fig. 64.

Sphenopteris (Davallia) distans: Schimper, 1869, p. 390.

Diplothmema distans: Stur, 1877, p. 137, pl. XV (XXXII), figs. 2–5; pl. XVII (XXXIII), fig. 1.

Sphenopteris bermudensiformis: Zeiller, 1899, p. 6, pl. 1, figs. 6–7, text-fig. 1; Gothan, 1923, p. 44, pl. 11, fig. 1; Radchenko, 1954, p. 14, pl. 11, figs. 2–6; Zimmermann, 1956, pp. 165–166, 189, pl. XXVIII, fig. 4; Sagan, 1965, p. 256, pls. I–X.

Diplothmema bermudensiformis: Gothan, 1913, p. 73, pl. 15, fig. 5; Kidston, 1923, p. 251, pl. LXI, figs. 3, 3a, pl. LXVII, figs. 3, 3a; Novik, 1952, p. 280, pl. XLVI, figs. 3a, 4, 4a, and 5; pl. XLIII, fig. 7b.

Lyginopteris bermudensiformis: Novik, 1968, p. 163, pl. XXXIX, figs. 1–5; pl. XL, figs. 1–5; Purkynová, 1970, p. 208, pl. 35, figs. 3, 3a; pl. 36, figs. 1–3; 1985, p. 56, pl. IX, figs. 4–6; 1988, p. 177, pl. VI, fig. 2; 2000, p. 251, pl. II, fig. 3.

Lyginodendron bermudensiforme: Kotasowa, 1968, pl. XIX, figs. 6–7.

Description. The material includes incomplete ultimate pinnae, which are up to 20 mm long, and branches, which are 7–9 mm wide and are covered with a distinct punctuated sculpture (=scars of shed glandular hairs; Pl. 12, fig. 5). The hairs are up to 1 mm in length and hooked or perpendicular to the surface of the branches. The ultimate rachis is longitudinally striate, up to 0.5 mm thick, and bears alternating, widely spaced, wedge-shaped-rounded pinnules (3–6 mm long and 3–4 mm wide). In the lower part of the pinna, the pinnules have three to five lobes; in the upper part, they are entire. The upper margin of the pinnules is toothed or slightly undulating. There are five to seven pinnules on the ultimate pinna. Lateral veins deviate from the solitary midvein and enter each lobe of the pinnules.

Comparison. The species under description most closely resembles the Viséan species *Sphenopteris schoenknechtii* (Stur) Kidston (Kidston, 1923) in the morphology and size of the frond and in the outline and arrangement of pinnules, but differs from the latter mostly in having wedge-shaped pinnae with a slightly serrate upper margin. In addition, the pinnules of *S. distans* are larger (3–6 mm long and 3–4 mm wide) than the roundish, apically rounded pinnules of *S. schoenknechtii* (which are only 2–3 mm long and 2.5–3 mm wide).

Remarks. Several detached cupules were discovered near an ultimate pinna of *S. distans* on one of the specimens under study. It is quite possible that they belong to the same plant. The surface of the shoots of this plant was densely covered with glandular hairs. Such hairs may have served to increase absorption and retention of moisture in the tissues of the plant and regulate transpiration and light absorption/reflection in shady sites (Miroslavov, 1974). It is not inconceivable that *S. distans* were lianas.

Occurrence. Lower Carboniferous of Europe and Asia: Tournaisian of Ukraine (Lviv region); Viséan of Great Britain, Germany, the Czech Republic, Poland, Ukraine (Donetsk region), Kazakhstan (Karaganda region), and Russia (Putlino and Jogla formations of the Upper Viséan, Novgorod region); and Serpukhovian (=Namurian) of Belgium, Poland, the Czech Republic, Bulgaria, and Ukraine (Donetsk region).

Material. Twenty-four specimens include impressions and counterparts of pinnae of different orders, stems, rachises, and detached pinnules.

Sphenopteris foliolata Stur, 1875

Plate 10, fig. 8

Sphenopteris foliolata: Stur, 1875, p. 22, pl. 5, figs. 3–6; Kidston, 1923, p. 113, pl. XXIII, figs. 1–4; Lutz, 1933, pp. 146–147, pl. XIX, fig. 9.

Diplothmema foliolatum: Stur, 1877, p. 124.

Sphenopteris (Lyginopteris) foliolata: Purkynová, 1970, p. 185, pl. 24, figs. 1–2b; 1985, p. 53, pl. IX, fig. 8.

Eusphenopteris foliolata: van Amerom, 1975, pp. 76–79, pl. XLIII, figs. 4–6.

Sphenopteris schillingsii: Balashov *et al.*, 1992, p. 47, text-fig. 12.

Description. The fragmentary ultimate pinna is about 30 mm long. The ultimate rachis is thin and bears alternating, rounded-triangular pinnules, which are up to 15 mm in length and 14 mm in width. The distance between the pinnules is about 12–15 mm. The pinnules are divided into three or four oval lobes: the apical lobe is 3–6 mm long and 5–8 mm wide, and the two or three lateral lobes are 5–7 mm long and 7–9 mm wide. Oddly, a solitary lateral lobe on one side is usually slightly wider than all the other opposite lateral lobes (one or two) combined. The pinnules are distinct, have a high relief, and are perpendicular to the rachis. Venation is also prominent: a solitary vein enters the lobe and dichotomizes up to four times into numerous radial veins.

Comparison. *Sphenopteris foliolata* most closely resembles *S. scribanii* van Amerom (van Amerom, 1975) in the morphology and shape of the pinnules. However, *S. foliolata* differs from the latter in that its pinnules are widely spaced, convex, rounded-triangular, and perpendicular to the rachis (the pinnule length is approximately equal to its width). *S. scribanii* has oval, flat pinnules, which are attached to the rachis at an acute angle. Formerly, we determined this specimen as *S. schillingsii* Andrae (Balashov *et al.*, 1992, p. 47, text-fig. 12). The species under consideration shows a certain resemblance to *S. schillingsii* but differs from it in the more rounded pinnules and more prominent rachis (see also Stur, 1875, p. 23; van Amerom, 1975, p. 77).

Occurrence. Lower Carboniferous of Europe: Tournaisian of Germany and Russia (Ural Mountains);

Viséan of the Czech Republic, Great Britain, Poland, and Russia (Upper Viséan, Putlino and Jogla formations, Novgorod region); and Serpukhovian (=Namurian) of Bulgaria.

Material. Six specimens, including four impressions and two counterparts of ultimate pinnae and isolated pinnules.

SUBCLASS MEDULLOSIDAE

Order Medullosales (Trigonocarpales)

Family Medullosaceae Sterzel, 1896

Genus *Rhynchogonium* Heer, 1876

***Rhynchogonium sulcatum* (Lindley et Hutton) Zalessky, 1905**

Plate 10, fig. 9

Carpolithes sulcata: Lindley and Hutton, 1837, p. 179 (220), text-figs. 1–6.

Rhynchogonium sulcatum: Zalessky, 1905, pp. 331–341, text-figs. 28–29; Crookall, 1976, pp. 943–944, pl. CLXXIII, figs. 2–5, 7; Balashov *et al.*, 1992, p. 47, text-fig. 13.

Lectotype. The specimen was figured by Lindley and Hutton (1837) in text-fig. 1 [designated here]. The collection number and current depository are unknown. The specimen was collected near the town of New Haven, Lower Carboniferous of Great Britain.

Description. The seed cupule has preserved as a three-dimensional body, which is 3.3 cm long and 1.7 and 0.6 cm wide at its midsection and base, respectively. The upper surface shows distinct longitudinal plications, which reflect cupule lobes. There are eight plications at the base of the cupule. Each plication dichotomizes at least three times, thus resulting in 46 plications in the middle of the cupule. The stalk of the cupule is clearly defined, becomes narrower downward, and is 1 cm in length and 0.6 cm in diameter in its upper part.

Comparison. *Rhynchogonium sulcatum* most closely resembles the Late Viséan species *R. fayettevillense* White (Crookall, 1976) but differs from the latter in being larger in size (approximately by a factor of 1.5–2) and in having fewer plications at the base of the cupule (8 and 12–15, respectively).

Remarks. The cupule of *Rhynchogonium sulcatum* supposedly enclosed seeds of *Boroviczia*. After the death of the parent plant, its parts were separated and fossilized as isolated remains. This hypothesis was first offered by Crookall (1976), who also proposed a new combination, *Rhynchogonium karpinskii* (Zal.) Crookall. However, we believe that this combination should not be applied, unless cupules of *Rhynchogonium* are found in organic connection with seeds of *Boroviczia*.

Occurrence. Viséan of Norway (Spitsbergen), Great Britain (Scotland), and Russia (Upper Viséan, Putlino and Jogla formations, Novgorod region).

Material. One cast of a cupule.

ACKNOWLEDGMENTS

This study was supported by the Special Federal Program for Integration (project nos. S-0050, E-0116, and E-0383).

REFERENCES

1. H. W. J. van Amerom, "Die eusphenopteridischen Pteridophyllen aus der Sammlung des geologischen Bureaus in Heerlen, unter besonderer Berücksichtigung ihrer Stratigraphie bezüglich des Südlimburger Kohlenreviers," Meded. Rijks Geol. Dienst, Ser. C **III-1** (7), 1–208 (1975).
2. Z. G. Balashov, A. T. Burakova, V. I. Volgin, *et al.*, *Handbook for Identification of Paleozoic Fossils of the St. Petersburg and Novgorod Regions (for Practical Works in Geology): Carboniferous System* (S.-Peterb. Gos. Univ., St. Petersburg, 1992) [in Russian].
3. A. Brongniart, *Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans diverses couches du globe* (Paris, 1828), Vol. 1.
4. R. C. Crookall, "Fossil Plants of the Carboniferous Rocks of Great Britain," Mem. Geol. Surv. Great Britain, Palaeontol. **4** (7), 841–1004 (1976).
5. C. R. Ettingshausen, "Die fossile Flora des mährisch-schlesischen Dachschiefers", Denkschr. Kais. Akad. Wiss. Wien. Math.-Naturwiss. Cl. **25**, 77–116 (1865).
6. H. R. Goeppert, *Die Gattungen der fossilen Pflanzen* (Bonn, 1841), pp. 1–36.
7. W. Gothan, "Die oberschleische Steinkohlenflora. 1. Farne und Farnähnliche Gewächse (Cycadofilicaces bezw. Pteridospermen)," Abh. K. Preuss. Geol. Landes., N. Folge **75**, 1–278 (1913).
8. W. Gothan, [in W. Gürich] "Karbon und Perm-Pflanzen," Leitfossilien, No. 3, 44 (1923).
9. *International Code of Botanical Nomenclature (Tokyo Code), Regnum Vegetabile, 131*, Ed. by W. Greuter *et al.* (Koeltz Scientific Books, Königstein, 1994).
10. R. Kidston, "Fossil Plants of the Carboniferous Rocks of Great Britain," Mem. Geol. Surv. Great Britain, Palaeontol. **2**, 1–681 (1923).
11. A. Kotasowa, "Flora karbonu productywnego w północno-wschodniej części zagłębia górnośląskiego (Rejon Dąbrowski)," Prace Inst. Geol. Warszawa **52**, 1–88 (1968).
12. J. Kvaček, and M. Straková, *Catalogue of Fossil Plants Described in Works of Kaspar M. Sternberg* (National Museum, Prague, 1997).
13. J. Lindley and W. Hutton, *The Fossil Flora of Great Britain or Figures and Descriptions of the Vegetable Remains Found in a Fossil State in This Country*, (James Ridgway & Sons, London, 1837), Vol. 3, pp. 123–205.
14. J. Lutz, "Zur Kulmflora von Geigen bei Hof," Palaeontogr. Abt. B, Palaeophytol. **78** (3–6), 114–157 (1933).
15. E. A. Miroslavov, *The Structure and Function of Epidermis in the Leaf of Angiosperms* (Nauka, Leningrad, 1974) [in Russian].
16. E. O. Novik, "Carboniferous Flora of the European Part of the USSR," Paleontol. SSSR, Nov. Ser. **1** (468), (1952).

17. E. O. Novik, *Early Carboniferous Flora of the Donets Basin and Its Western Extension* (Naukova Dumka, Kiev, 1968) [in Russian].
18. O. A. Orlova, "Plant Remains of Tulan Age (Early Carboniferous) from the S.A. Dobrov Collection at the V.I. Vernadsky Geological Museum," in *The Second Yanshin Memorial Lectures of Young Scientists on Current Issues in Geology* (Nauchnyi Mir, Moscow, 2002), pp. 309–312.
19. O. A. Orlova and S. M. Snigirevsky, "Late Visean Lyginopteridophytes from the Vicinity of the Town of Borovichi (Novgorod Region): 1. Calamopityales," Paleontol. Zh., No. 6, 105–111 (2003) [Paleontol. J. **37** (6), 665–671 (2003)].
20. K. Patteisky, *Die Geologie und Fossilführung der mährisch-schlesischen Dachschiefer- und Grauwackenformation* (Naturwissenschaftliche Verein, Opava (Troppau), 1929).
21. E. Purkynová, "Die Unternaturflora des Beckens von Horni Slezsko (CSSR)," Paläontol. Abh. Abt. B, Paläobot. **3** (2), 129–268 (1970).
22. E. Purkynová, "Fosilni z kulmu Drahanske vrchoviny," Čas. Slez. Muz. Opava (A) **34**, 43–64 (1985).
23. E. Purkynová, "Makroflora kyjovickeho souvrstvi moravskoslezskeho kulmu a jeji vyznam," Čas. Slez. Muz. Opava (A) **37**, 173–182 (1988).
24. E. Purkynová, "Kulmska flora z podloži němčičske uhelne palvę na jižni Moravé (moravskoslezske paleozoikum)," Čas. Slez. Muz. Opava (A) **49**, 247–252 (2000).
25. M. I. Radchenko, *Lower Carboniferous Flora of the Karaganda Formation in the Karaganda Basin* (Akad. Nauk Kaz. SSR, Alma-Ata, 1954), pp. 14–16 [in Russian].
26. *Resolutions of the Interdepartmental Regional Stratigraphic Conference on the Middle and Upper Paleozoic of the Russian Platform with Regional Stratigraphic Schemes* (Vses. Geol. Inst., Leningrad, 1990) [in Russian].
27. E. Sagan, "Nowe szczegóły morfolgiczne paproci nasiennej *Sphenopteris bermudensiformis* (Schloth.) Behrend," Biul. Inst. Geol. Warszawa **11**, 247–270 (1965).
28. W. Schimper, *Traité de paléontologie végétale ou la flore du monde primitif* (J.B. Baillière et fils, Paris, 1869), Vol. 1.
29. E. F. Schlotheim, *Die Petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Samlung versteinerter und fossiler überreste des Tier- und Pflanzenreichs der Vorvelt erläutert. Abt. II. Das Pflanzenreich* (Gotha, 1820).
30. S. M. Snigirevsky, "Vittsa Rapids: Lower Carboniferous," in *Fossil Plant Localities Requiring Protection* (St. Petersburg, 1994), pp. 59–60 [in Russian].
31. G. K. Sternberg, *Versuch einer geognostischen botanischen Darstellung der flora der Vorwelt* (F. Fleischer, Leipzig, 1820), Vol. 1, Parts 1–2, pp. 1–24, 1–33 (Ernst Brenck's Wittwe, Regensburg, 1823), Vol. 1, Parts 3–4, pp. 1–39, 1–48 (Johann Spurny, Prague, 1833), Vol. 2, Parts 5–6, pp. 1–80 (Gotlieb Hässe Söhne, Prague, 1838), Vol. 2, Parts 7–8, pp. 81–220.
32. D. Stur, "Die Culm-Flora des mährisch-schlesischen Dachschiefers," Abh. Kais.-Kön. Geol. Reichsanst., **8** (1), 1–106 (1875).
33. D. Stur, "Die Culm-Flora der Ostrauer und Waldenburgen Schichten," Abh. Kais.-Kön. Geol. Reichsanst. **8** (2), 1–366 (1877).
34. H. Tschirkova, "Végétaux houillers inférieurs du versant oriental de l'Oural," Bull. Soc. Géol. France, Sér. 5 **3**, 521–532 (1934).
35. J. Walton, "Contributions to the Knowledge of Lower Carboniferous Plants: III. On the Fossil-Flora of the Black Limestones in Teilia Quarry, Gwaenysgor, Near Prestatyn, Flintshire, with Special Reference to *Diplopteridium teilianum* Kidston sp. (gen. nov.) and Some Other Fern-Like Fronds," Phil. Trans. R. Soc. London. Ser. B **219**, 347–379 (1931).
36. E. Weiss, *Aus der Flora der Steinkohlenformation. Zur Erläut der wichtigeren Pflanzen dieser Formation, mit besonderer Berücksichtigung der Steikohlengebiete*, (Schropp, Berlin, 1881), pp. 3–25.
37. M. D. Zalesskii, "Plant Fossils from Lower Carboniferous Deposits of the Msta River Basin," Zap. Imper. Mineral. O–va **42** (2), 313–342 (1905).
38. M. D. Zalessky, "Ueber Früchte aus den Untercarbonablagerungen des Msta-Beckens in Nord-Russland," Izv. Imp. Akad. Nauk **22** (3), 113–120 (1905).
39. R. Zeiller, "Étude sur la flore fossile du bassin houiller D'Héraclée," Mém. Soc. Géol. France, Paléontol. **8** (4), 1–91 (1899).
40. F. Zimmermann, "Notes on the Palaeobotany of the Lower Silesian Carboniferous: The Flora Accompanying the Marine Culm Fauna in the Area of Ptasia Góra (Ptasia Hill) near Walbrzych Miasto," Biul. Inst. Geol. Warszawa **2**, 125–202 (1956).
41. F. Zimmermann, *Die Phylogenie der Pflanzen*, 2nd ed. (Stuttgart, Gustav Fischer, 1959).