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New Species of *Samaropsis* from the Gzhelian of the Donets Basin

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Abstract—Two new species *Samaropsis bachmutiensis* sp. nov. and *S. spinifera* sp. nov. are described on the basis of seed remains from the Gzhelian Stage of the Donets Basin. The seed impressions associated with rare remains of cordaites and conifers and abundant pteridosperm remains were found in floodplain-lacustrine and floodplain deposits.

INTRODUCTION

The seeds of the genus *Samaropsis* Goppert are widespread in the Carboniferous and Permian strata of many basins.

The heterogeneous formal genus *Samaropsis* comprises seeds of different gymnosperms. According to its original diagnosis (Goppert, 1864-1865), subsequent interpretation (Potonie, 1893; Seward, 1917), and detailed descriptions (Florin, 1940; Neiburg, 1965; Sukhov, 1969; Ignat'ev, 1987), the genus includes flattened seeds of different outlines and sizes with a distinct wide wing-shaped border. The border is notched near the micropyle and the point of seed attachment.

The majority of scientists dealing with Paleozoic seeds assign *Samaropsis* to cordaites. Such an attribution is evidenced by the occurrence of seeds of this genus in the inflorescences of *Cordaitanthus* from the Westphalian of France and Great Britain (Grand'Eury, 1877; Arnold, 1949). Seeds of several species of the genus are known to be associated with the leaves of *Rufloria* Meyen and *Cordaites* linger from the Permian of the Pechora River Basin (Ignat'ev, 1987). At the same time, Stschegolev (1958) proposed the affinity of some Carboniferous species of *Samaropsis* to conifers.

In the Donets Basin, seeds of *Samaropsis* are known from the Middle and Upper Carboniferous deposits. Novik (1951, 1952) discovered *Samaropsis pitcairniae* (Lindl. et Hutt.) Zeill., *Samaropsis fluitans* (Dawson) Weiss, emend. Zeill., *S.* cf. *alata* Kidst., *S. emarginata* (Goepp. et Berg.) Kidst., and *S. orbicularis* (Ettingsh.) Cook in the Bashkirian and Moscovian stages (Middle Carboniferous). Stschegolev (1958) described from the upper part of the Isaevskaya Formation (Moscovian) seeds of *Samaropsis delafondii* (Zeill.) Florin var. *acuminata* Stscheg. and *S. pinnata* Stscheg. associated with the conifers *Lebachia* aff. *hypnoides* (Brongn.) Florin and *Lebachia piniformis* (Schloth. pars) Florin. In the Araucarian Formation (Gzhelian), Zalessky (1937) discovered *Samaropsis naumichensis* Zal. in association with the pteridosperms *Sphenopteris scythica* Zal. and *Odontopteris naumichana* Zal. and seeds of *Samaropsis moravica* (Helmhacker) Sew., renamed by Arber (1914) to *Samarospermum moravicum* (Helmhacker) Arber.

MATERIAL

The present paper describes new species of *Samaropsis* from the Upper Gzhelian of the Donets Basin. The material is housed at the Institute of Geological Sciences of the National Academy of Sciences of Ukraine (IGS). The seeds in question were buried separately from vegetative parts of plants.

The heterogeneous systematic composition of fossil plant assemblages is determined by the diversity of plant communities constituting the parent plants producing these seeds. Abundant remains of leaves and isolated seeds, satisfactory preservation of specimens, and lithofacial characteristics of the host rock indicate a relatively rich vegetation of river valley slopes and adjacent territories, constituted by plants, fossilized in floodplain and lacustrine-floodplain deposits.

The assemblage is dominated by pteridosperms with callipterid foliage ascribed to the genera *Autunia* Krasser, emend. Kerp and *Lodevia* Haubold et Kerp (mostly ultimate and penultimate pinnae). Pteridosperm remains of the genera *Neuropteris* Sternb. and *Odontopteris* Brongn. (fragmentary ultimate pinnae with several or single pinnules) are less abundant. Remains of conifers (isolated branchlets) and cordaites (leaf fragments) occur even more rarely.

Among dispersed seeds, small flattened seeds associated with peltaspermous pteridosperms of the genus *Autunia* and radiosymmetrical middle-sized seeds of *Trigonocarpus* Brongn. prevail. Flattened winged seeds belonging to *Samarospermum* and *Samaropsis* are less abundant.

The holotype of *S. bachmutiensis* sp. nov. (IGS, no. 2216/18) was found in greenish gray, indistinctly bedded, micaceous siltstone in association with plant remains of *Lodevia suberosa* (Sterzel) Haub. et Kerp, *Neuropteris auriculata* Brongn., *Calamites suckowii* Brongn., and *Cordaites* sp. Specimen IGS, no. 2216/19 comes from greenish gray indistinctly bedded siltstone, with uneven fracture, in association with several impressions of the pteridosperm *Neuropteris* sp.

The holotype of *Samaropsis spinifera* (IGS, no. 2216/20) was found in greenish gray, indistinctly bedded, in places, ferruginous, slightly micaceous, and, in places, sandy siltstone. The same bed contained impressions of *Samarospermum moravicum* (Helmhacker) Arber; the pteridosperms *Odontopteris subcrenulata* (Rost) Zeiller, *O. osmundaeformis* (Schloth.) Zeiller, *Lodevia nicklesii* (Zeiller) Haub. et Kerp, *L. suberosa* (Sterzel) Haub. et Kerp, and *Autunia naumanii* (Gutbier) Kerp; and the conifers *Walchia* cf. *whitei* Florin. Specimen IGS, no. 2216/21 was found in greenish gray, compact, indistinctly bedded, in places, horizontally bedded siltstone. The assemblage contains seed impressions of *Trigonocarpus* sp., remains of the pteridosperms *Odontopteris osmundaeformis, O. brardi, Alethopteris rubescens* Stbg., *Autunia naumannii,* and the conifer *Walchia* cf. *frondosa* Renault. Specimen IGS, no. 2216/22 was found in greenish gray, indistinctly bedded, and slightly micaceous siltstone. The assemblage also includes seeds of *Trigonocarpus* sp. and *Samarospermum moravicum* and remains of *Neuropteris* cf. *planchardii* Zeiller, *Walchia* sp., and *Cordaites* sp.

SYSTEMATIC PALEOBOTANY

DIVISION PINOPHYTA (GYMNOSPERMAE) S.V. MEYEN, 1987

Genus *Samaropsis* Goppert, 1864

Samaropsis bachmutiensis Boyarina, sp. nov.

Etymology. After the locality of the Bakhmutskaya Depression.

Holotype. IGS, no. 2216/18; Donets Basin, left bank of the Mironovskoe Reservoir, opposite the village of Luganskoe, under coal bed p_5 below limestone P_5^1; Upper Carboniferous, Gzhelian Stage, Araucarian Formation.

Diagnosis. Seeds rounded triangular, with wide rounded base and narrowed apex, about 8-10 mm long and 8 mm wide. Nucellus roundish, about 5-6 mm long and 4-5 mm wide. Nucellar base rounded with small pit; apical part tapered and acute. Nucellar surface with slightly marked longitudinally arched rugae. Wing 2-2.5 mm wide in basal part and 1 mm wide in apical part, uniformly surrounding nucellus. Apical border of wing with small sinus. Basal border with small triangular or oblong sinus. Wing surface striated; in basal part, finely bosselated.

Description (Figs. 1A, 1B). The seeds are small, 8-10 mm long and 8 mm wide, rounded triangular, with a broad rounded base and narrowed apex. The nucellus is 5-6 mm long and 4-5 mm wide, rounded, has an acuminate attenuated micropylar part, and is situated in the central region of the seed. The chalazal part of the nucellus is rounded with a small pit (Figs. 1A, la) or small semicircular sinus (Figs. 1B, lb). The surface of the nucellus is covered with fine longitudinally arched rugae; centrally, it possesses an indistinct groove. The wing-shaped epispermal border, uniformly surrounding the nucellus, is 2-2.5 mm wide at the seed base and 1 mm wide at the apex. The narrowed border of the seed apex bears a small sinus. Basally, the border has a superficial triangular (Figs. 1A, la) or slightly elongate notch (Figs. 1B, lb), which might correspond to the point of seed attachment. The surface of the border has arched striae and is finely bosselated in the lower part.

Comparison. In the specific rounded nucellus with an acuminate attenuated micropylar part, the new species is similar to *Samaropsis naumichensis* Zal., *S. moracia* Zal., *S. pinnata* Stscheg., *S. intaensis* Neub., *S. insignis* Tschirk, and 5. *euryptera* Suchov. The new species differs from the first two species in the more than two times smaller seed of rounded triangular outline. The seed of *Samaropsis naumichensis,* depicted by Zalessky (1937), shows a rounded and apically acuminate nucellus uniformly flanked by a narrow wing-shaped border, which is apically and basally lacerated or tucked. The new species is distinguished from the other species listed above by the rounded triangular outline of the seed, whereas in *S. pinnata,* the seeds are elliptical; in *S. insignis,* the seeds are rounded tetragonal; and in *S. moracia, S. euryptera,* and *S. intaensis,* the seeds are rounded.

The species resembling the new one in the outline of the nucellus differ in the seed orientation. According to the original descriptions, *S. moracia, S. euryptera,* and *S. intaensis* have a basally acuminate nucellus. In the first two species, the acuminate base of the nucellus reaches a small acute-angled sinus in the basal margin of the episperm. According to the author of *S. intaensis,* this species has either a stalk or a germinating radicle in the seed base (Neiburg, 1965). In the former case, the region near the seedstalk is the seed base. In the latter case, i.e., taking this appendage as a germinating radicle, the region in question is the micropylar region of the seed. In *S. insignis,* which closely resemble *S. intaensis* in seed morphology, the acuminate part of the nucellus is in the apical region, while the base has an appendage projecting out of a notch in the border; in the original description, this appendage is treated as a seedstalk. The seed orientation in the new species is accepted in the present study on the basis of the conventional interpretation of the morphology of the seed apex and base.

Material. Two impressions of good and satisfactory preservation from different beds of the same locality.

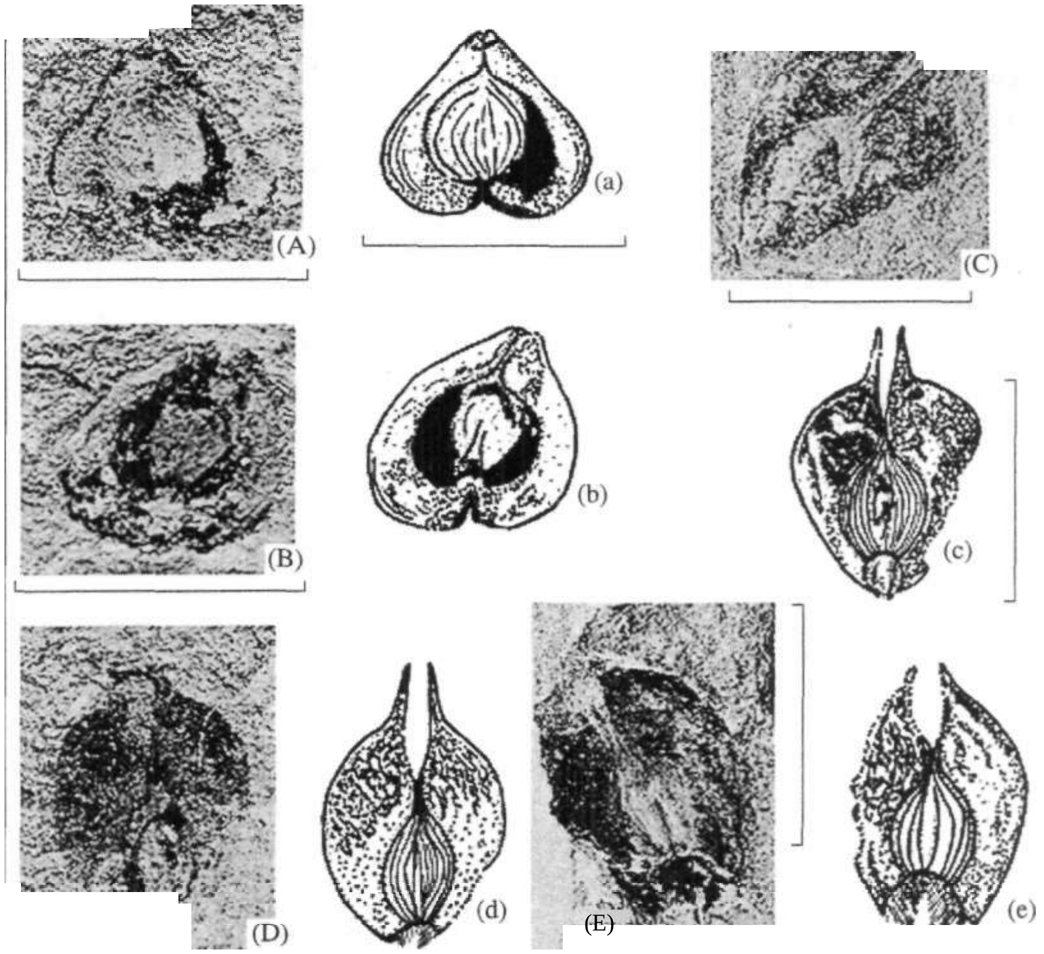

Fig. 1. Isolated seeds of *Samaropsis* from the Gzhelian Stage, left bank of the Mironovskoe Reservoir, Donets Basin: (A, B, a, b) *Samaropsis bachmutiensis* sp. nov.: (A) holotype IGS, no. 2216/18; (a) drawing of IGS, no. 2216/18; (B) 1GS, no. 2216/19; (b) drawing of IGS, no. 2216/19; (C-E, c-e) *Samaropsis spinifera* sp. nov.; (C) holotype IGS, no. 2216/20; (c) drawing of IGS, no. 2216/20; (D) IGS, no. 2216/21; (d) drawing of IGS, no. 2216/21; (E) IGS, no. 2216/22; (e) drawing of IGS, no. 2216/22. Scale bar, 1 cm.

***Samaropsis spinifera* Boyarina, sp. nov.**

Etymology. From the Latin *spina* (spine) and *fera* (bearing).

Holotype. IGS, no. 2216/20; Donets Basin, left bank of the Mironovskoe Reservoir, opposite the village of Luganskoe, under coal bed p_5 below limestone P_5^1; Upper Carboniferous, Gzhelian Stage, Araucarian Formation.

Diagnosis. Seeds ovoid, with wide apical part, about 10-12 mm long and 7-8 mm wide. Nucellus elliptical, located at seed base, about 5-6 mm long and 3-4 mm wide. Nucellar apex pointed and extending to oblong sinus in apical part of wing; nucellar base with half-round pit. Nucellar surface bearing arched longitudinal rugae. Wing 1-1.5 mm wide basally and becoming 3.5-4 mm wide apically. Wing apical border having wedge-shaped sinus with two straight spinelike processes about 2 mm long. Wing basal border with two lateral extensions and half-round pit.

Description (Figs. 1C-1E). The seeds are small, 10-12 mm long and 7-8 mm wide, obovate. The outlines vary from obovate (Figs. 1C, lc) to slightly elongate (Figs. lD-le). In the former case, the seed resembles an isosceles triangle with the base situated near the seed apex and the sides equal to 8 mm, lacking spinelike processes. The nucellus is 5-6 mm long and 3-4 mm wide, elliptical, displaced to the seed base. The micropylar region of the nucellus is acuminate and reaches the elongate notch in the apical part of the episperm border. The chalazal part of the nucellus has a semicircular pit and closely adjoins the rounded sinus in the base of the border. The surface of the nucellus is covered with arched longitudinal rugae extending from the chalazal to the micropylar part. In the chalazal part of the nucellus, the rugae diverge from the entire border of the shallow sinus and converge to the micropylar region (Figs. 1E, le). Basally, the winged episperm embraces the nucellus like a narrow border (1-1.5 mm wide); toward the apex, it widens up to 3.5-4 mm. The border is finely striated. Apically, the episperm is divided by a narrowly wedge-shaped elongated notch into two straight spinelike processes up to 2 mm long. The sides of the notch are straight (Figs. 1C, lc, 1D, 1d) or slightly concave (Figs. 1E, le). Basally, the border forms two lateral protrusions around a wide semicircular sinus. Below the sinus, there is a wedge-shaped protrusion 2 mm long and 1.7 mm wide with a distinct central rib (Figs. 1C, 1c) or its distinct concave impression 2-3 mm wide (Figs. 1D, 1d, 1E, le). This protrusion might be either a seedstalk or integumentary expansion. In the latter case, the basal part of the seed of *S. spinifera* sp. nov. consists of two narrowing lateral protrusions and one median wedge-shape expansion of the integument.

Comparison. The new species differs from other species of *Samaropsis* in the combination of the ovoid outline and wide apical epispermal border with two straight spinelike processes of the integument. The new species is similar to *Samaropsis polymorpha* Neub. in the presence of these processes, differing, however, in the basal position of the nucellus, widened apical part of the border, and a narrower sinus between the spinelike processes.

Remarks. Seeds with two acute hornlike protrusions on the apex are commonly assigned to *Cornucarpus* Arber, emend. Halle. According to Arber (1914), this genus embraces triangular seeds devoid of a wing, with a narrowed base and a broader apex bearing two lateral hornlike protrusions, and, occasionally, with a longitudinal rib in the middle. Halle (1927) proposed that *Cornucarpus* includes not only seeds lacking a wing-shaped border but also winged seeds with two horns and with or without a median rib. Apart from the well-pronounced hornlike processes, the seeds of *Cornucarpus* are characterized by predominantly elongated triangular or elongated elliptical outlines, a narrow epispermal border, and a large nucellus occupying a large part of the seed. The broad wing-shaped border, a small distinct elliptical nucellus displaced to the seed base distinguish the seeds under study from the seeds of *Cornucarpus*, supporting their assignment to the genus *Samaropsis.*

A similar seed base was described in seeds of the Late Permian conifer *Ortiseia* Florin emend. Clement-Westerhof (Clement-Westerhof, 1984).

Material. Three well-preserved specimens from three beds of the same locality.

CONCLUSION

Although the seeds of the two new species are nearly equal in size, they significantly differ in morphology and are associated with the foliage of different fossil plants. From a wide range of plants putatively related with the seeds described above, we should exclude trigonocarpous pteridosperms (which have radiosymmetrical seeds) and pteridosperms with callipterid foliage (small platispermic seeds) (Kerp, 1988). Seeds of *S. bachmutiensis* are distinguished by their rounded nucellus, broad cordate-emarginate base, and moderately narrow wing-shaped border. They were found in association with fragments of cordaite foliages. Seeds of 5. *spinifera* sp. nov. have elliptical nucellus, a broad wing-shaped apical border with two integumentary horns, and two lateral protrusions of the integument around the semicircular sinus in the seed base; these seeds are elements of the plant assemblages containing conifers.

Thus, the morphological features of the seeds described in the present study and the composition of the plant assemblages corroborate the heterogeneity of the formal genus *Samaropsis.*

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