ISSN 0031-0301, Paleontological Journal, 2007, Vol. 41, No. 11, pp. 1103–1107. © Pleiades Publishing, Ltd., 2007.

A New Species of *Tatarina* S. Meyen and the Problem of Differentiation between Some Late Permian Peltasperms on the Basis of Epidermal Characters

E. V. Karasev

Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117997 Russia
e-mail: karasev@paleo.ru

Received February 15, 2007

Abstract—A new species, *Tatarina rinatata*, is described from continental deposits near the village of Nedubrovo, Vologda Region, Russia, belonging to the base of the Vetlugian Series of the transitional Permian–Triassic aspect. Problems of differentiating between leaves of the genus *Tatarina* based on epidermal characters are discussed.

DOI: 10.1134/S0031030107110093

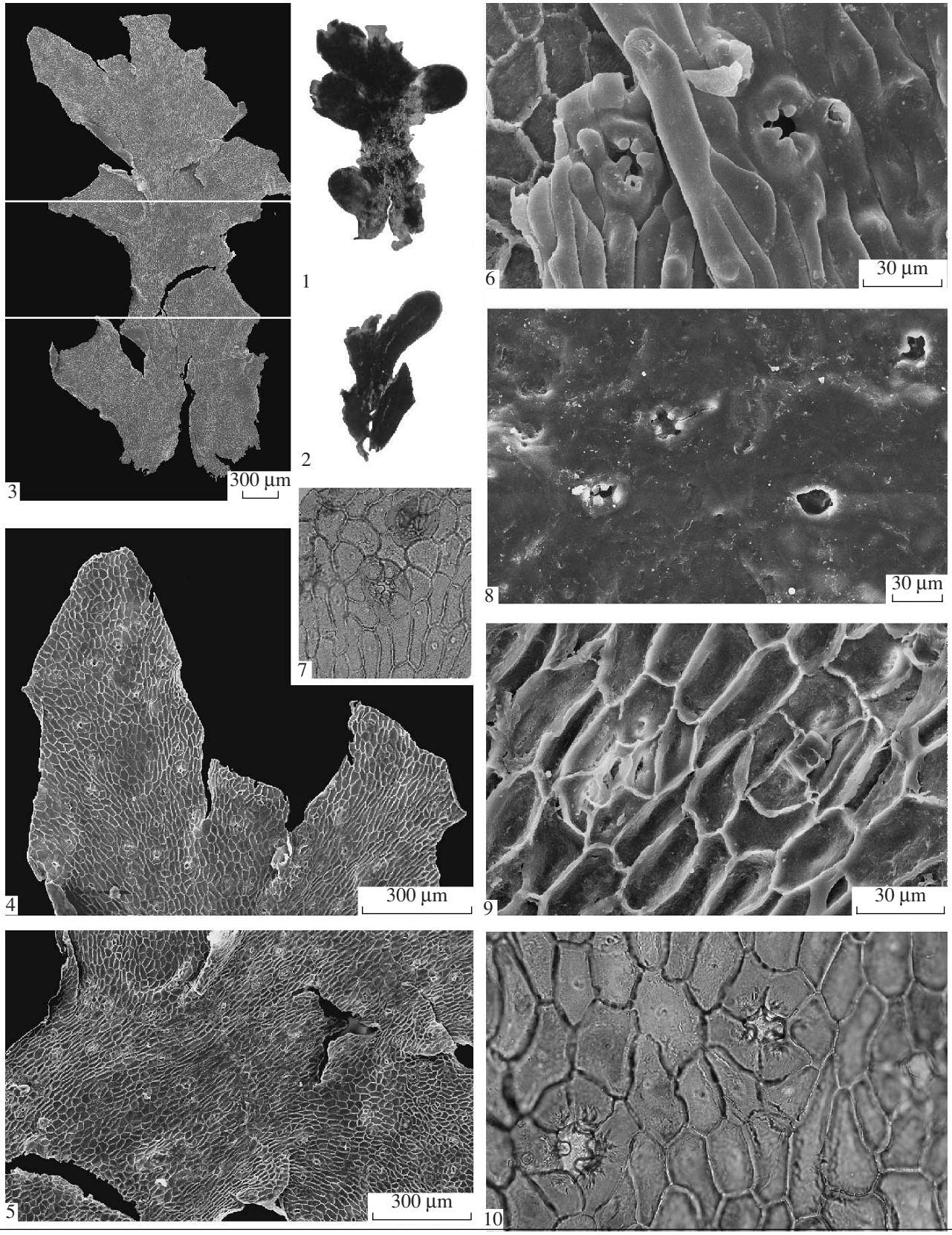
Key words: Peltasperms, *Tatarina*, Tatarian stage, Vetlugian Series, systematics.

INTRODUCTION

The Late Permian time on the Russian Platform is characterized by the dominance of peltasperms, with prominent *Tatarina* S. Meyen, which was established by Meyen (1969) as a result of his revision of *Pursongia* Zalessky. The new generic name was introduced for leaves similar to *Pursongia* in general morphology but with thoroughly studied microstructure. The old name was retained for leaf impressions without compressions. Meyen (1969) published the diagnosis of the genus and described the type species *Tatarina olferievii* S. Meyen for entire-margined obovate to narrowly lanceolate or linear leaves. Later, Gomankov and Meyen (1979) described entire-margined leaves of *T. conspicua* S. Meyen and pinnate leaves of *T. pinnata* S. Meyen et Gomankov. Meyen and Gomankov (1980) described *T. sinuosa* Gomankov and *T. verrucosa* Gomankov from the Vyatkian horizon of the Vologda Region and *T. lobata* S. Meyen and *T. sadovnikovii* S. Meyen from the Korvunchanskian Series of the Tunguska River Basin. For the first time, tongue-shaped lobate leaves, *T. lobata*, were assigned to the genus. The authors also noticed a morphological similarity between *Tatarina* and *Tersiella* Radczenko from the Kuznetsk and Tunguska basins. However, the absence of original specimens of the type species of *Tersiella*, *T. beloussovae* Radczenko, prevented them from treating *Tatarina* as a junior synonym of *Tersiella*, which is, in turn, a junior synonym of *Pursongia*.

Later, a monograph devoted to the *Tatarina* flora was published, where Gomankov and Meyen (1986) considerably extended the species *T. conspicua.* They included *T. sinuosa* and *T. verrucosa* in *T. conspicua* because transitional forms were discovered between their marginal morphotypes. Modifications were introduced for marginal forms that are remarkably different from *T. conspicua* in its original concept, but are connected with this species by continuous transitional forms. The Latin name of a modification is placed after the specific epithet and reflects the characteristic feature of this modification. In some cases, the name of the modification corresponds to the former specific name. However, these authors emphasized that the modifications are defined only because of their morphological "peculiarity," and it is possible that they do not correspond to peaks in abundance and are not geographically restricted. One more species, *T. mira* Meyen, was described. The genus became wider and wider because new morphotypes were added. Gomankov and Meyen (1986, p. 81) wrote in the description of *T. mira* that "this species occupies a kind of a transitional position between *T. conspicua* and *T. pinnata* in general morphology and epidermal structure." Meyen proposed a morphological trend from pinnatifid leaves of *T. pinnata* to lobed leaves of *T. lobata* and entire-margined leaves of most *Tatarina* species. From nearly coeval deposits, Naugolnykh (2006) described entire-margined leaves with available epidermal characteristics as a member of *Pursongia*, considering *Tatarina as* a junior synonym of *Pursongia*. In my opinion these leaves differ considerably from *Tatarina* in their epidermal morphology, in particular, in the cutinization of the guard cells. I share the opinion of Gomankov and Meyen (1986) that this character has a high taxonomic value. The typically *Tatarina-like* cutinization of guard cells is shown in Fig. 1. The consideration of the two genera as a single natural taxon and the treatment of *Tatarina* as a junior synonym of *Pursongia* seems

Plate 9



untimely and requires additional study. The generic name *Pursongia* should be retained for leaf impressions without compressions.

Earlier, *T. conspicua* and *T. lobata* were determined from the Nedubrovo locality (Krassilov et al., 1999). *T. conspicua* is common on the Russian Platform. However, the other six species of *Tatarina*, including the species described in the present paper, only occur in association with *T. conspicua.* The analysis of *T. conspicua* and its modifications shows that this species differs from other members of the genus in one to three epidermal characters, such as the degree of development of papillae, sinuosity of the anticlinal walls, and cutinization of subsidiary cells, which are often adaptive features in modern plants and vary within individual species (Larcher, 1976; Lotova, 2000). Thus, the type species *T. olferievii* only differs from *T. conspicua* mod. *virgata* in the less distinct papillae on the epidermal cells. As the group under study is totally extinct, it is difficult to estimate the true taxonomic value of characters, whether they are features of intraspecific variability or specific characters. Since the described species of *Tatarina* are poorly delineated morphotypes with unclear ranges of variability, the existing concept of differentiation between the species of this genus is far from natural taxonomy.

MATERIAL AND METHODS

The material was collected by S.A. Afonin, N.V. Gordenko, V.A. Krassilov, and N.E. Zavialova (Paleontological Institute, Russian Academy of Sciences, PIN) and V.R. Lozovsky (Russian Geological Prospecting University) from the Permian–Triassic continental deposits of the Nedubrovo locality (Krassilov et al., 1999). The locality is situated in the Kichmenga River basin, the left tributary of the Yug River, near the village of Nedubrovo, Vologda Region, Russia (Lozovsky et al., 2001). The section is formed by speckled clays and marls of the Tatarian Stage, overlain by cross-bedded and pebbly sandstones of the Astakhinskian (Vetlugian superhorizon), facially replaced by reddish-brown clays (up to 3 m thick) or greenish-gray up to rose-colored thin-bedded siltstones with abundant plant debris on bedding planes (Krassilov et al., 1999).

Plant remains were extracted from thin-bedded fine- to medium-grained poorly cemented quartz sandstones and from lignite sublayers where they formed mass accumulations. The material is represented by fragmentary leaf compressions and dispersed cuticles.

The terminology developed by Gomankov and Meyen (1986, text-figs. 13, 15) is used for the description of the epidermal morphology of compressions. A structure surrounding the stomatal pit from the outside is referred to as a Florin ring, an elevated ring-shaped structure formed by papilla-bearing periclinal walls of subsidiary cells (terminology of Anderson and Anderson, 1989).

Compressions were macerated using the standard technique: treated first with nitric acid and then with KOH. The samples obtained were studied with an AXIOPLAN-2 light microscope and CAMSCAN scanning electron microscope. Collection no. 4820 is housed at the Paleontological Institute, Russian Academy of Sciences, (PIN).

SYSTEMATIC PALEOBOTANY

Order Peltaspermales

Family Peltaspermaceae Thomas, 1933

Genus *Tatarina* S. Meyen, 1969

***Tatarina rinatata* Karasev, sp. nov.**

Plate 9, figs. 1–10

Etymology. Anagram of *Tatarina*.

Holotype. PIN, no. 4820/1; fragment of the middle part of a pinnatifid leaf; Nedubrovo locality, near the village of Nedubrovo, left bank of the Kichmenga River, Vologda Region; Nedubrovo beds, Vokhminskian horizon, Vetlugian superhorizon, Upper Permian–Lower Triassic (Pl. 9, figs. 1, 3).

Diagnosis. Leaves pinnatifid. Segments tongue-shaped entire-margined with rounded apex. Leaves amphistomatic. Stomata regularly distributed, irregularly orientated, and monocyclic. Epidermal cells rectangular and longitudinally elongated. In axial zone, periclinal walls swollen in form of longitudinally elongated rim; hairs present. Subsidiary cells four to six, trapezoidal, with large proximal papilla.

Description (Fig. 1). Leaves are pinnatifid (Pl. 9, figs. 1–3). The fragments are 1.9–2.2 mm wide. The complete leaves are at least 2.5 mm wide. The fragments are 2.5–4.0 mm long. Segments are tongue-shaped. The segment apices vary from slightly elongated to rounded. The segments are 0.6–1.3 mm long and about 0.5 mm wide. The segments are entire-mar-

Explanation of Plate 9

Figs. 1–10. *Tatarina rinatata* sp. nov: (1, 3–5, 8–10) holotype PIN, no. 4820/1; (1) general view of the leaf, ×10; (3) inner surface of the cuticle of the lower epidermis of a segmented leaf; (4) inner surface of the cuticle of the lower epidermis of a leaf segment; (5) inner surface of the cuticle of the lower epidermis, axial area of a leaf; (8) outer surface of the upper cuticle; (9) stomatal apparatuses of the lower epidermis, note guard cells; (10) stomatal apparatuses of the lower epidermis, note cutinized subsidiary cells, ×500; (2, 6, 7) PIN, no. 4820/2; (2) general view of a leaf, ×5; (6) outer surface of the lower epidermis; (7) stomatal apparatuses of the upper epidermis, note starlike cutinization of subsidiary cells, ×330; (3–6, 8, 9) SEM; (7, 10) LM; (1–10) Nedubrovo locality, near the village of Nedubrovo, left bank of the Kichmenga River, Vologda Region; Nedubrovo beds, Vokhminskian horizon, Vetlugian superhorizon, Upper Permian–Lower Triassic.

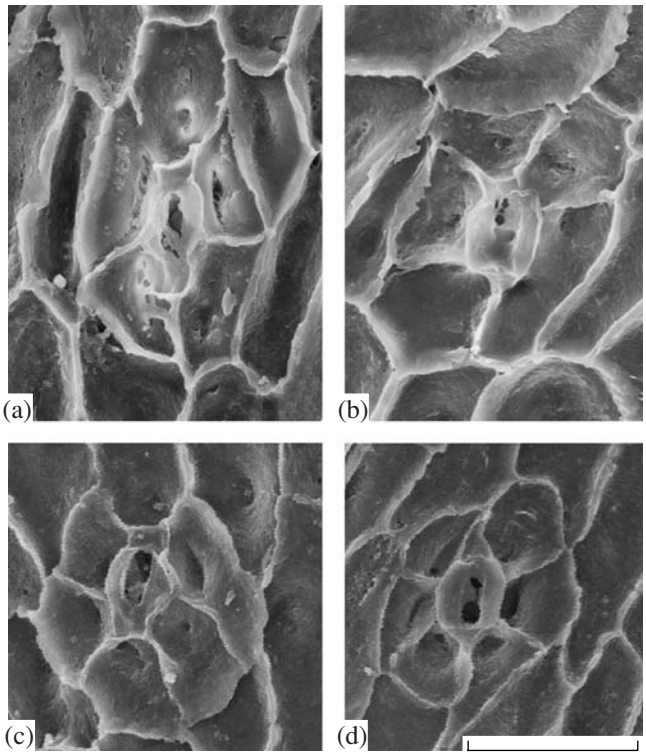


Fig. 1. Cutinization of guard cells in *Tatarina rinatata* sp. nov.: (a, b) wide and long polar appendages of guard cells; (c) polar appendages of guard cells, one wide and one narrow; (d) nearly undeveloped narrow polar appendages. Scale bar 30 μm.

gined. A poorly defined axial zone is traceable on the lower side, corresponding to a false midrib. The venation of segments is radiate-dichotomous. The veins dichotomize at least once.

Leaves are amphistomatic. The upper and lower sides are equally cutinized, but the stomatal densities are different. The side with a better developed axial zone and closely spaced stomata is assumed to be the lower (abaxial) side of the leaf.

In the axial zone of the lower side, epidermal cells are longitudinally elongated forming more or less straight rows. In some regions, usually in lateral segments, they form an isogonal structure. There is no differentiation into costal and intercostal zones. The rows of epidermal cells deviate from the rows of the axial zone at an angle of about 25° and enter segments (Pl. 9, figs. 4, 5). The density of epidermal cells is 1296–1728 per square millimeter. Stomata are irregularly distributed (and irregularly orientated) over the entire lower surface of the leaf blade, avoiding marginal zones. The stomatal density is 32–68 per square millimeter, up to 80 in the axial zone. The stomatal index is 4.6–4.8. In segments, epidermal cells are rounded-rectangular, longitudinally elongated, 6–20 μm wide and 20–75 μm long. The anticlinal walls are curved or, more rarely, straight. The periclinal walls are smooth on the inside, occasionally with small depressions corresponding to the bases of papillae. The bases of papillae are 5–10 μm in diameter. In the axial zone of the leaf, the periclinal walls are swollen, form longitudinally elongated rims, and occasionally have hairs up to 30 μm long (Pl. 9, fig. 6).

The stomata are monocyclic, with four to six trapezoidal subsidiary cells. There is nearly no differentiation into polar and lateral subsidiary cells. The cutinization of subsidiary cells is starlike. The contour formed by the distal walls of subsidiary cells varies from irregular to rounded and convex, 38–57 μm in diameter (Pl. 9, figs. 9, 10). The periclinal walls are papillose; papillae are median, large, inclined toward the stomatal pit. A Florin ring is distinct. The guard cells are bean-shaped, sunken, with polar appendages, on average 15 μm long and 11.3 μm wide. When polar subsidiary cells are developed, polar appendages are wide, distinct, and dovetailed (Figs. 1a, 1b). When polar subsidiary cells are not expressed, polar appendages are either narrow or virtually undeveloped (Figs. 1b, 1d).

Cells of the upper epidermis are arranged in rows or form an isogonal structure both in the axial zone and in the segments (Pl. 9, fig. 7). Periclinal walls bear small and poorly defined papillae at the center of the segment and large papillae on the margins of the segment. Papillae on subsidiary cells vary from proximal and distinct to median and poorly defined. A Florin ring is either undeveloped or weakly developed (Pl. 9, fig. 8). In the lower epidermis, the density of ordinary epidermal cells is 1970–2200 per square millimeter. The stomatal density is 100–106 per square millimeter.

C o m p a r i s o n. In leaf blade morphology, the new species is similar to *T. mira* and *T. lobata*, which have similar weakly dissected leaves. It differs from *T. mira* in the outline and position of epidermal cells. On the upper side of the epidermis of *T. rinatata* sp. nov., epidermal cells are elongated and are arranged in rows, not isogonal. Unlike *T. mira*, the new species shows no differentiation of epidermal cells into costal and intercostal zones on the lower side of the epidermis; stomata are irregularly distributed. *T. rinatata* sp. nov. differs from *T. lobata* in the presence of deeper dissected smaller lobes, epidermal cells arranged in rows, and weakly developed papillae on the upper leaf surface. The new species is distinct from other species of *Tatarina* (*T. olferievii, T. pinnata*, and *T. conspicua*) both in the leaf blade morphology and epidermal structure. These three species have leaf blades either entire-margined or dissected into linear segments and stomata arranged in distinct zones or rows.

R e m a r k s. Gomankov and Meyen (1986) believed that starlike cutinization of subsidiary cells is a character of high taxonomic value and a distinctive feature of *T. mira.* However, I found such a cutinization in *T. rinatata* sp. nov. and *T. lobata* from the Nedubrovo locality; thus, its taxonomic value was overestimated. This character, like other epidermal characters within the genus *Tatarina*, is not specific to any particular species; the

species are only distinguished by combinations of characters. It was also shown that starlike cutinization is not formed at the expense of thickened radial anticlinal walls of subsidiary cells, as was supposed by Gomankov and Meyen (1986), but mostly at the expense of additionally cutinized inner periclinal walls near the contact with guard cells.

T. rinatata sp. nov. has a place within a line of transitional leaf morphotypes: from divided leaf blade (*T. rinatata* sp. nov.) to lobed leaf blade (*T. lobata* and *T. mira*) and to entire leaf blade (*T. olferievii* and *T. conspicua*), typical of *Tatarina*. In the diagnosis of *Tatarina*, Meyen mentioned sunken and weakly cutinized guard cells (Gomankov and Meyen, 1986). Electron microscopy has revealed details of the cutinization in guard cells of *Tatarina.* The development of polar appendages varies within a single specimen (Fig. 1). Guard cells with and nearly without distinct appendages occur together. This questions the validity of *Tatarinopsis* Gomankov, described from the Upper Kazanian of the Shikhovo-Tchirkee locality on the basis of dispersed cuticles (Gomankov, 1987). According to Gomankov (1987), the main distinguishing feature of this genus is the absence of polar appendages, in contrast to *Tatarina*, which always has well-developed appendages.

M a t e r i a l. Two compressions of fragmentary pinnatifid leaves and dispersed cuticles.

ACKNOWLEDGMENTS

I am grateful to V.A. Krassilov and N.V. Gordenko for valuable comments and discussion of this paper.

The study was supported by the grants of PalSIRP Sepkoski (no. RUG1-1648-XX-06) and Systematics Research Funding.

REFERENCES

1. J. M. Anderson and H. M. Anderson, *Palaeoflora of Southern Africa, II* (A.A. Balkema, Rotterdam, 1989).
2. A. V. Gomankov, "Dispersed Cuticles from the Shikhovo-Tchirkee Locality (the Kazanian Stage of the Vyatka River)," Paleontol. Zh., No. 2, 33–39 (1997) [Paleontol. J. **31** (2), 154–160 (1997[MB1])].
3. A. V. Gomankov and S. V. Meyen, "On Representatives of the Family Peltaspermaceae from the Permian Deposits of the Russian Platform," Paleontol. Zh., No. 2, 124–138 (1979).
4. A. V. Gomankov and S. V. Meyen, *Tatarina Flora (Taxonomic Composition and Distribution in the Late Permian of Eurasia): Proc. Geol. Inst., Acad. Sci. USSR, Issue 401* (Nauka, Moscow, 1986) [in Russian].
5. V. A. Krassilov, S. A. Afonin, and V. R. Lozovsky, "Floristic Evidence of Transitional Permian–Triassic Deposits of the Volga–Dvina Region," Permophiles, No. 34, 12–14 (1999).
6. W. Larcher, *Ökologie der Pflanzen* (Eugen Ulmer, Stuttgart, 1976; Mir, Moscow, 1978).
7. L. I. Lotova, *Morphology and Anatomy of Higher Plants* (Editorial URSS, Moscow, 2000) [in Russian].
8. V. R. Lozovsky, V. A. Krassilov, S. A. Afonin, et al., "On Recognition of a New Member within the Vokhma Formation of the Lower Triassic of the Moscow Syneclise," Byull. Region. Mezhved. Stratigr. Komissii po Tsentru i Yugu Russkoi Platformy, No. 3, 151–163 (2001).
9. S. V. Meyen, "On the Genus *Zamiopteris* Schmalhausen and Its Interrelationship with Some Related Genera," in *Pteridosperms* of the Upper Paleozoic and Mesozoic: Proc. Geol. Inst., Acad. Sci. USSR, Issue **190** (Nauka, Moscow, 1969), pp. 85–104 [in Russian].
10. S. V. Meyen and A. V. Gomankov, "Peltaspermous Pteridosperms of the Genus *Tatarina*," Paleontol. Zh., No. 2, 116–132 (1980).
11. S. V. Naugolnykh, "Vyazniki Flora and the Nature of the Permian–Triassic Extinction," in *Cause-and-Effect Relationships and Factors of the Global Biospheric Turnovers in the Phanerozoic: Proc. Geol. Inst., Ross. Acad. Sci.., Issue 580* (GEOS, Moscow, 2006), pp. 83–89 [in Russian].