Floristic Evidence of Transitional Permian-Triassic Deposits of the Volga - Dvina Region

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It was long believed that transitional Permian-Triassic deposits did not exist in the area of the classical Kazanian and Tatarian stages. The boundary between the latest Tatarian (the Upper Vyatkian Member) and the lowermost Vetlugian (the Astashikhian Member with *Lystrosaurus*) was described as unconformable (Lozovsky & Esaulova, 1998), but the hiatus might not be uniform over the basin, apparently decreasing in the central part at the Volga-Severnaya Dvina watershed. A rich fossil flora is known from the Vyatkian (Gomankov & Meyen, 1986), whereas the Astashikhian lacks any reliable plant macrofossil record. The typical Early Triassic *Pleuromeia* assemblage first appeared upsection in the Ryabian Member.

We found plant macrofossils, megaspores, and palynological assemblages in the basal Vetlugian (Astashikhian) indicating a possible transitional Permian-Triassic age. The fossil plant locality occurs on the left bank of Kichmenga River near Nedubrovo Village, Vologda Region (Fig. 1). In the Kichmenga section, the late Tatarian (Vyatkian) variegate marl - clay deposits are overlain by the Astashikhian cross-bedded sands and pebble beds (8 m) followed by the reddish brown clay (3 m) and by alternate thin-bedded greenish-gray to purple siltstones and shales (2.5 m) with abundant plant debris on the bedding surfaces. The plant remains are fragmentary but with well preserved cuticles providing epidermal characteristics that are important for classification of the Permian and Triassic gymnosperms. Of certain stratigraphic significance are the following gymnosperm taxa (Fig. 2):

Tatarina S. Meyen, a peltasperm leaf genus typical of the Tatarian flora. Morphological diversity of tatarinas increases in the Vyatkian where they form leaf mats and large accumulations of dispersed cuticles. No tatarinas were hitherto reported from any strata above the Vyatkian in the stratotype area. Stratigraphic relationships of the Vyatkian tatarinas with two species recorded from the Tungusska intertrappean deposits of Siberia remain uncertain. In the Nedubrovo locality tatarinas are abundantly represented by at least two well-defined species. Of these, *Tatarina conspicua* S. Meyen is a numerically dominant species of both the Vyatkian (Gomankov & Meyen, 1986) and Astashikhian plant assemblages. Our material from Nedubrovo, studied with SEM, shows files of irregularly spaced stomata with a distinct Florin ring. The epidermal cells are densely papillate, as in the *verrucosa* variety of this polymorphic species.

Another species, *Tatarina lobata* S. Meyen has been previously described from intertrappean deposits of Korvunchan Formation in the Tungusska Basin (Meyen & Gomankov, 1980). This species differs from the Vyatkian tatarinas in the lobed margin of the narrow lanceolate leaves as well as in the scattered stomata with proximally papillate subsidiary cells. The Nedubrovo specimens show all the diagnostic features of the species but are smaller than the type specimens and more heavily papillate - a feature shared with *T. conspicua*.

Phylladoderma Neuburg, another Late Permian peltasperm genus, is most abundant in the Kazanian, but subordinate to

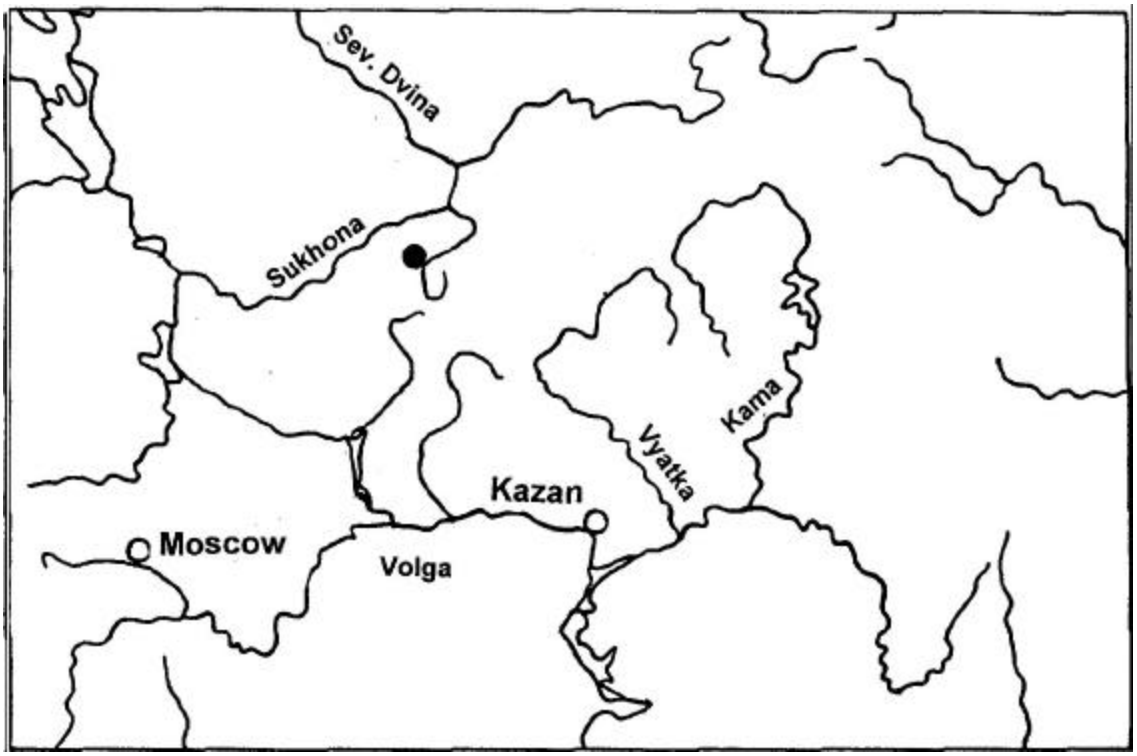

Figure 1. Sketch map of the Volga - Severnaya Dvina watershed region showing geographic position of the Nedubrovo plant locality (black circle).

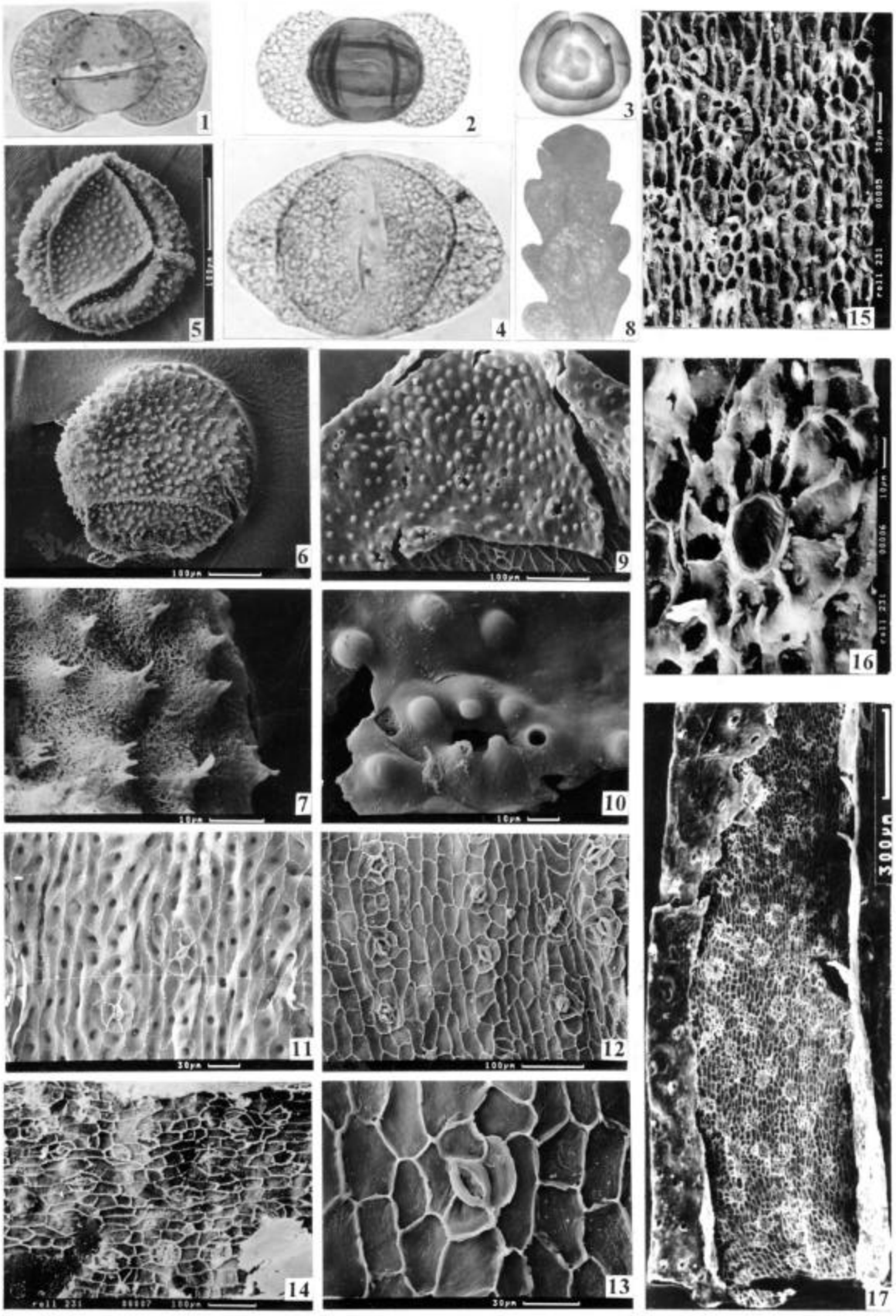

Figure 2. Characteristic plant fossils of the lower Astashikhian assemblage at Nedubrovo, light and SEM micrographs: 1 - bisaccate taeniate pollen grain Lunatisporites noviaulensis *(Leschik) Foster, 2 - bisaccate bitaeniate pollen grain* Lueckisporites virkkiae *Potonie et Klaus (Visscher (s form A); 3 - trilete spore* Polycingulatisporites *sp. 4 - bisaccate non-taeniate pollen grain* Klausipollenites schaubergeri *(Potonie et Klaus) Jansonius, 5-7 - megaspore* Otynisporites eotriassicus *Fugl., proximal and lateral views, appendages, 8-10 - peltasperm* Tatarina lobata *S. Meyen, leaf fragment, cuticle, papillate stoma; 11-13 - peltasperm* Tatatrina conspicua *S. Meyen, cuticle of typical and heavily papillate varieties, stoma; 14 - conifer* Quadrocladus solmsii *(Gothan et Nagalhard) Schweitzer, mid-leaf cuticle; 15-17 - conifer* Ullmannia cf. bronnii *Goepp., group of five contiguous stomata, stoma and whole leaf cuticle (light micrographs 1-4, 625x, 8, 15x)*

Tatarina in the Tatarian. In Nedubrovo it is represented by *Phylladoderma (Aequistomia) annulata* Meyen that is characterized by polygonal epidermal cells and irregularly orientated small stomata uniformly scattered over both leaf surfaces except along the leaf margins marked by narrow stomata-free zones of elongate cells. The species has been previously recorded from at least three localities in the upper Tatarian (Gomankov & Meyen, 1986).

Ullmannia Goeppert is a typical Zechsteinian conifer that has been occasionally reported also from the Volga Basin. All such finds were recently transferred to *Quadrocladus* or *Steirophyllum* that are morphologically similar to *Ullmannia*, but differ in epidermal characteristics (Meyen, 1997). Unexpectedly, some conifer leaves from Nedubrovo showed stomata in irregular files, with up to 12 subsidiary cells which are diagnostic epidermal features of *U. bronnii* Goepert. Two other conifer species from Nedubrovo belong to *Quadrocladus solmsii* (Gothan et Nagalhard) Schweitzer, a Zechsteinian species fairly distinct from the Tatarian quadroclades, and *Pseudovoltzia* similar to the Permian Alpine species *P. sjerpii* Clement-Westerhof (1987).

Notably, all the Nedubrovo gymnosperms show frequent epidermal anomalies, such as irregular epidermal topography, contiguous stomata, with up to five stomatal complexes sharing their subsidiary cells, giant stomata, etc. Since these plants grew at the time of massive Siberian trap volcanism and since aerosol particles form volcanic eruptions enhance destruction of stratospheric ozone, the abnormal epidermal features might have been related to an excess UV radiation.

The diverse megaspore assemblage comprises *Otynisporites eotriassicus* Fugl. (Fig. 2), index species of the *Otynisporites* zone comprising the basal Suboolitic Member of Buntsandstein immediately above the Zechstein (Fuglievich, 1977 and elsewhere). Outside Europe *Otynisporites eotriassicus* occurs in the upper Guodikeng Formation of the Junggar Basin, northern China (Liu, 1994) containing a mixed vertebrate assemblage with *Dicynodon* and *Lystrosaurus.*

The palynological assemblage is dominated by *Klausipollenites* and *Cycadopites* (up to 30% each). The Zechsteinian elements, such as *Striatoabieites richteri* (Klaus) Hart, *Lunatisporites noviaulensis* (Leschik) Foster, *L. pellucidus* (Goubin) Helby, *Lueckisporites virkkiae* Potonie et Klaus (form A: Visscher et al., 1973) are more prominent than in the Lower Griesbachian *Protohaploxypinus* assemblage (Balme, 1979; Utting, 1994). At the same time abundant *Tympanicysta*, fungal remains, a considerable diversity of trilete spores, including *Polycingulatisporites* and *Densoisporites*, and the asaccate *Cycadopites* give this assemblage a transitional Permian-Triassic aspect. Preliminary floristic comparisons suggest a possible correlation of the lowermost Vetlugian with the uppermost plant-bearing horizon of the Upper Changhsingian of South China. In the Tieqiao Section, Laibin County, the plant-bearing bed occurs immediately below the trangsgressive terminal Changhsingian (Jin & al., 1998 and our unpublished data).

We conclude that:

(1) The Nedubrovo plant assemblage of the lowermost Vetlugian (Astashikhian) retained a Permian aspect. It is dominated by *Tatarina* species survived from the Tatarian.

(2) On account of *Tatarina lobata* the basal Vetlugian corresponds to the lower intertrappean deposits of the Tungusska Basin. The Astashikhian gymnosperms are extremely xeromorphic. They also show frequent epidermal anomalies perhaps related to an excess UV radiation owing to contemporaneous trap volcanism and associated atmospheric phenomena.

(3) The Astashikhian conifers include *Ullmannia cf. bronnii*, *Quadrocladus solmsii* and other characteristic Zechsteinian species not known in the Tatarian.

(4) The presence of megaspores *Otonisporites eotriassicus* suggests correlation with the lowermost Buntsandstein of Central-Eastern Europe and with the upper Guodikeng Formation of Junggar Basin in China.

(5) The Astashikhian palynological assemblage is of a mixed Zechsteinian - Lower Griesbachian composition suggesting a more continuous transboundary floristic succession than in central Europe and Eastern Greenland. Correlation with the upper Changhsingian is a possibility requiring further studies.

References

Balme B.E., 1979, Palynology of Permian-Triassic boundary beds at Kap Stosch, East Greenland. Medd. Groenland 200: 1-37.

Clement-Westerhof, J.A., 1987, Aspects of Permian palaeobotany and palynology, VII. The Majonicaceae, a new family of Late Permian conifers. Rev. Palaeobot. Palynol. 52: 375-402.

Fuglewicz, R., 1977, New species of megaspores from the Trias of Poland. Acta Palaeont. Pol. 22: 406-431.

Gomankov, A.V. & Meyen, S.V., 1986, The Tatarinian flora (composition and distribution in the Late Permian of Eurasia). Moscow: Nauka, 174 p.

Jin,Yugan, Sheilong, Mei, Wei, Wang , Xiangdong,Wang , Shuzhong, Shen, Quinghua, Shang, Zhongqiang, Chen, 1998, On the Lopingian Series of the Permian System. Palaeoworld 9: 1-81.

Liu, Shuwen, 1994, The nonmarine Permian-Triassic boundary and Triassic conchostracan fossils in China. Albertiana 13: 12-24.

Lozovsky, V.R. & Esaulova, N.K., 1998, The Permian-Triassic boundary in the continental sequences of Eastern Europe. Moscow: Geios, 245 p.

Meyen, S.V., 1997, Permian conifers of Western Angaraland. Rev. Palaeobot. Palynol. 96: 351-447.

Meyen, S.V. & Gomankov, A.V., 1980, Peltasperm pteridosperms of the genus Tatarina. Paleont. J. (Moscow) 2: 116-132.

Utting, J., 1994, Palynostratigraphy of Permian and Lower Triassic rocks, Sverdrup Basin, Canadian Arctic Archipelago. Geol. Surv.Canada Bull. 478: 1-107.

Visscher H., 1973, The Upper Permian of Western Europe - a palynological approach to chronostratigraphy. In Logan A. & Hills L.V. (editors) The Permian and Triassic systems and their mutual boundary. Canadian Soc. Petrol.. Geol., Mem. 2: 200-219.