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Scanning electron microscopy as a key to the recognition of the cross-field types in fossil coniferous wood from the Arctic*

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ABSTRACT. Some new data on Arctic fossil coniferous wood are presented. The well-defined borders and slit-like apertures of cross-field pits which appeared to be simple under the light microscope were observed under the scanning electron microscope. The "podocarpoid" cross-field pits of many Mesozoic wood samples, in association with data on podocarpous pollen, have enabled us to hypothesize the distribution of podocarps under the anomalous warm climate experienced in high latitudes from the Lower Triassic to the Neogene.

KEY WORDS: fossil coniferous wood, cross-field, Mesozoic, Arctic

The anatomical study of Mesozoic Arctic coniferous wood in different localities of Eastern Siberia has revealed some difficulties in recognizing the cross-field pit types under the light microscope (LM). It is known that the nature of the cross-field pits, and their distribution patterns, that is pitting, are very important for the diagnosis of fossil coniferous wood. Now it is clear that their classification and recognition are impossible without scanning electron microscopy (SEM).

Simple techniques were used on Upper Permian and Lower Triassic wood which was fractured into small fragments prior to SEM examination. These were then treated with hydrochloric acid (10%), washed and boiled on the microscope slides in hydrogene peroxide for 1–2 min. Washed and dried fragments have been set up the SEM stage.

The comparative pictures under the LM and SEM are portrayed in the Figures 1, 2 show one of the new types of coniferous wood from the Lower Triassic of the Tunguska Basin which has been named *Septomedulloxylon putoranicum* Snig., Gromyko et Mogutcheva (in press), while Figure 3 show the star-like complex of pits in the cross-fields of *Araucarioxylon* sp. from the Upper Permian of the Taimyr Peninsula. This type of pitting is usual for many samples of Arctic Mesozoic wood. The present study has shown the very encouraging results to begained from using SEM techniques for the recognition of the pit types in the cross-fields of fossil wood.

As is shown in the Figure 2 the radial view under the LM shows pitting in the cross-fields. Uniseriate or linear rays in the wood are marked by marginal cross-fields, usually with 3–4 pits. These pits appear to be simple under the LM and differ very much from the pits with well-defined borders (usually 2–3 to 7) in the cross-fields from the middle of the same rays. Some other slides show that "simple" pits can also occur in the centrally situated cross-fields.

The difficulties of recognition presented by pit types with a slit-like aperture in living plants were discussed by Yatsenko-Khmelev-

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Fig. 1. *Septomedulloxylon putoranicum*. Cross-fields under SEM: well-preserved borders and wide inner apertures to the right; traces of narrower pit canals fowards the base of the fracture left and above (arrows). ×1500. Scale bar 10 mm

sky (1948, 1954) long before the SEM revolution in microscopy techniques occurred. His suggestion was “to identify as simple all slit-like pits with a border invisible under × 500 magnification. This demarcation is very important both for wood diagnosis and for uniformity in the designation of pits in wood elements”... (Yatsenko-Khmelevsky 1954 p. 17).

The problem of pit type identification in cross-fields under the LM is just as great for fossil wood, especially conifers. The wide variation in pit type is well-known in extant Pinaceae and Podocarpaceae s.l.; there are transitional types between bordered and simple. The exact determination of the cross-field pit types in combination with other features is an important element in wood identification.

A radial view of the cross-fields of *Septomedulloxylon putoranicum* under the LM shows that at least 3 types of “podocarpoid” (s.l.) pits are present. “Circoporoid” (sensu Vogellehner 1967) pits (usually 1–2) can be seen in Figure 2, bottom left and right. Bigger elliptical pits with well-defined borders (usually 2 to 5) occur in the middle cross-fields of the ray. There are pits (usually 3–4) lacking a visible border under the LM, in cross-fields possesing marginal ray cells. These have been traditionally described as “simple”.

SEM techniques appear to be applicable to both Permian and Triassic wood and have been used in the present study of coniferous wood. As is clear from Figure 1, the picture of the cross-field pits with clear borders at the margins (with 4 pits) is at least as good as that of thouse in the middle of the ray (with 2 pits). There is no horizontal or tangential pitting in the ray cells. The lens-like inner pit apertures pass obliquely from one pit margin to the next at an angle of about 50–60°. They are usually a little wider (at the surface) than the lateral

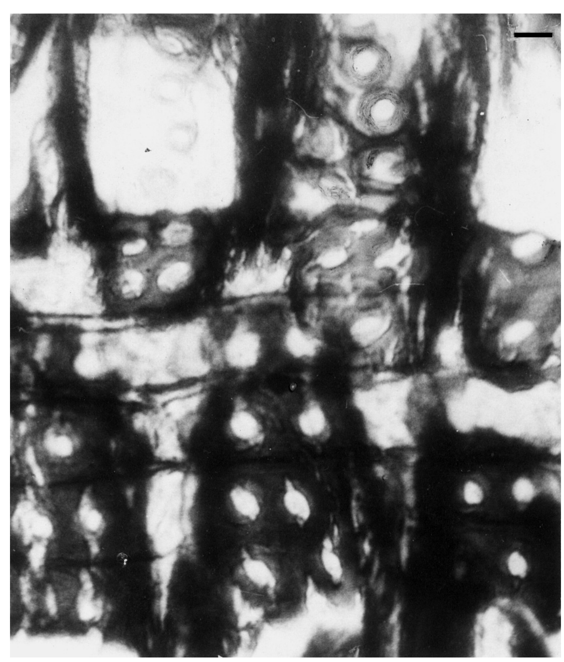

Fig. 2. “Podocarpoid” cross-fields of *Septomedulloxylon putoranicum* under LM: oblique slit-like apertures in the central part; 1, 2 “circoporoid” pits to the left and right, 3, 4 above left, in the marginal cross-fields. ×400. Tunguska Basin. Preparation N 776/1/3. Scale bar 10 mm

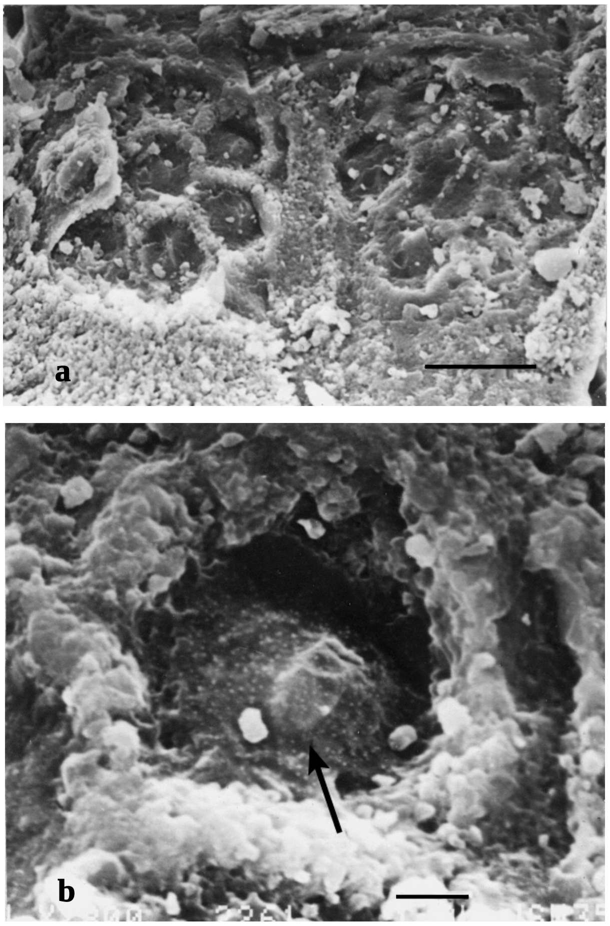

Fig. 3. Star-like pit complexes in the cross-fields of *Araucarioxylon* sp. with traces of slit-like apertures seen through the fractured walls of some pits (arrow). **a** – ×750. Scale bar 10 mm. **b** – ×3900. Scale bar 1 mm. Sample N 4/615

pit borders. A mineral substance is visible inside the pit canals, but it was necessary to half the treatment of the wood at this stage to prevent destruction of the cross-fields. Some neighbouring pits on the left have been broken at the primary wall or at deeper levels of the secondary wall, and the cross-section of the narrower pit canal is visible at the bottom (arrows). The SEM shows the bordered pits to be 10–12 mm in diameter, and they may be formed "dacrydioid". Similar but larger (to 16 mm diameter) pits, with anidentical oblique slit-like inner aperture, have been observed under the LM in *Dacrydium beccardii* Parlatore from Kalimantan (Borneo) (Greguss 1972). These apertures also traverse the whole pit beneath the surface ans the slit too is usually wider than the lateral borders. This species of *Dacrydium* possesses "podocarpoid" pits in combination with "cupressoid" ones in its marginal cross-fields.

The "podocarpoid" type of cross-field pit in *Septomedulloxylon* is associated with great variability in the pattern of cross-field pitting, even for a cross-field between a ray and a series of tracheids in contact (Fig. 2). *S. putoranicum* is identical in pitting type to *Dacrydium laxifolium* Hooker from New Zealand, but the latter species has smaller cross-field pits only 7–8 mm in diameter.

There is relatively little data on Triassic wood from the Arctic region. Shilkina (1984) described from the Tunguska Basin the Lower Triassic *Araucariorhizoxylon kryshtofovichii* Shilk., with taxodioid pits in its cross-fields and septate pith as in *Septomedulloxylon*. However, its relationship with the Araucariaceae is doubtful. Shilkina (1967), Shilkina and Chudajberdyev (1972) also recorded some coniferous wood in the Upper Triassic of Franz-Jozef Land, includiding *Protocedroxylon dibneri* (Shilk.) Shilk. et Chudajb. with simple round pits (usually 2, 3) in its cross-fields, *P. gregussii* (Shilk.) Shilk. et Chudajb. with cupressoid ones (usually 1, 2) and *Xenoxylon* cf. *latiporosum* (Cramer) Gothan with "window" pits. It is very important that all these species be studied under the SEM. As Chavchavadze (1979) showed, there are window-simple, pinoid-simple and pinoid-bordered cross-field pits in the wood of living conifers in the Podocarpaceae s. l. and the Pinaceae. Yatsenko-Khmelevsky (1954) noted great variation in most anatomical features of the podocarps' wood structure including their pits and the pitting of their cross-fields. Almost all the types of cross-field pit known in the extant conifers, namely piceoid, taxodioid, cupressoid, and window, have been recorded in the modern Podocarpaceae, divided now into several families.

There are star-like or "en marquerite" (Marguerier 1977) pits in Permian and Mesozoic wood from the Arctic region. This type of pit has been studied in the Upper Permian *Araucarioxylon* sp. (Figures 3a, b). As a rule 5–8 peripheral pits surround a central one in the middle of the star complex. Individual pits do not have a well defined slit in their surface but only a trace of a slit-like aperture inside the canal under the damaged membrane (arrow). All these pits have a thin rim (different from the border of all previous pits), marking their individual outlines. The central pit is usually round, but the rest are pentagonal and a little elongated radially in relation to the star complex. Individual pits measure 8–10 μm across. They seem to be sited on the ray cell walls and from a simple component of the pit-pair between a tracheid and a ray cell. The rim seems to be the result of fossilization of living ray cells.

As for *Septomedulloxylon putoranicum* itself, it has been likened to podocarpous wood on the basis of its cross-field structure. Podocarpous wood remains have been recorded also for the Jurassic of Novaja Zemlja (Backlund 1916, wood definition by M.D. Zalessky), for Frans-Jozef Land (Shilkina 1967, Shilkina & Yatsenko-Khmelevsky 1980), and for the Cretaceous of the Kirov region (Shilkina 1989). Podocarpous pollen, but never impressions have been described in the Cretaceous Arctic floras too. The discrepancies in the data between macrofloras and pollen have so far been discussed for West Kazakhstan (Vakhrameev 1952) and for the Arctic region (Bolkhovitina 1959, Pavlov 1963). The new data on fossil wood provides justification for the hypothesis that thermophilous podocarps would have felt at home in the anomalous warm climate (Snigirevskaya 1996a, b) found at high latitudes in association with the very intensive trappean magmas present in Northern Russia at the Permian-Triassic boundary (Savostin et al. 1984) and through the Mesozoic to the Neogene, under the prolonged influence of high geodynamic activity.

REFERENCES

BACKLUND O.O. 1916. Quelques données sur l'île de la Solitude (Ensomhed). Bull. Acad. Impér. Sci., 11: 913–920 (in Russian).

BOLKHOVITINA N.A. 1959. Spore and pollen assemblages of Mesozoic deposits in the Viluj Depression and their importance for stratigraphy. Trudy GIN AN SSSR, 24: 1–186 (in Russian).

CHAVCHAVADZE E.S. 1979. Coniferous woods. Leningrad.

GREGUSS P. 1972. Xylotomy of the living conifers. Budapest.

MARGUERIER J. 1977. Sur la punctuation simple dans les champs de croisement de quelques structures Paléozoiques et Mesozoiques. C.R. Congr. Nation. Soc. Sav. (Limoges, 1977), 1: 79–92.

PAVLOV V.V. 1963. Use of the complex method in describing the palaeobotanical characteristics of the Upper Cretaceous deposits in some regions of the Lena Basin. Sb. statej paleont. i biostrat. NIIGA. Leningrad: 68–78 (in Russian).

SAVOSTIN L.A., NATAPOV L.M., STAVSKY A.P. 1984. Mesozoic palaeogeodynamics and palaeogeography of the Arctic region. Tr. 27 Intern. Geol. Congr. Moscow, 1984. 3: 172–187 (in Russian).

SHILKINA I.A. 1967. Fossil woods of Franz-Josef Land. Palaeobotanika. Trudy BIN. Ser. 8, 6: 31–50 (in Russian).

SHILKINA I.A. 1984. New Lower Triassic genus *Araucariaceae* (?) from Eastern Siberia. Ezhegodnik Vses. Palaeontol. Obstch-va, 27: 103–105 (in Russian).

SHILKINA I.A. 1989. Coniferous woods from the Lower Cretaceous of the Kirov region (new species). Voprosy paleofloristiki i stratigraphii. Sbornik. Leningrad: 88–99 (in Russian).

SHILKINA I.A., CHUDAJBERDYEV R.Ch. 1972. New finds and a review of the genera *Protocedroxylon* and *Xenoxylon*. Paleobotanika Uzbekistana, 2: 117–133 (in Russian).

SHILKINA I.A., YATSENKO-KHMELEVSKY A.A. 1980. Some aspects of coniferous wood evolution in the Mesozoic. In: Systematics and evolution of the higher plants. Sb. Leningrad: 110–116 (in Russian).

SNIGIREVSKAYA N.S. 1996a. The Early Triassic is the time for the primary differentiation of conifers with mixed radial pitting of woods. Intern. Org. Palaeobot., V Quadr. Conf. Santa Barbara. CA. 1996: 92.

SNIGIREVSKAYA N.S. 1996b. Triassic "climatic optimum" in Northern Siberia and its importance for the evolution of Mesozoic conifers. Ibid.: 92.

VAKHRAMEEV V. A. 1952. Stratigraphy and fossil flora of Cretaceous deposits in West Kazakhstan. Moscow (in Russian).

VOGELLEHNER D. 1967. Zur Anatomie und Phylogenie Mesozoischer Gymnospermenhölzer. 5: Prodromus zu einer Monographie der *Protopinaceae*. I. Protopinoiden Hölzer von Trias. Palaeontographica, 121B (1–3): 30–51.

YATSENKO-KHMELEVSKY A. A. 1948. Principles of wood systematics. Trudy Botan. Inst. AN Arm. SSR, 5: 5–135 (in Russian).

YATSENKO-KHMELEVSKY A. A. 1954. Fundamentals and methods of anatomical studies of woods. Moscow (in Russian).