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New locality of *Callixylon* (Archaeopteridaceae) in the Late Devonian of Andoma Mountain (Vologda Region, north-west Russia) and its importance for the reconstruction of archaeopterids distribution

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ABSTRACT. A new record of *Callixylon* based on the anatomical study of wood from the Late Devonian of the Main Devonian Field (north-west of European Russia) has filled one of the lacune on the map of archaeopterids distribution. The new locality of this important genus is placed on the conserved territory of Geological Monument named Andoma Mountain (Andoma Gora). According to the palaeogeographic reconstruction this new Late Devonian locality of *Callixylon* was located inside the palaeo-equatorial zone.

KEY WORDS: archaeopterids, wood, taxonomy, anatomy, Late Devonian, geological monuments

INTRODUCTION

A new locality of *Callixylon trifilievii* Zalessky is reported here. One of the best known genera of Archaeopteridophyta (Snigirevskaya 2000) in the Late Devonian floras of the world, *Callixylon* was described by Zalessky (1909, 1911) from Famennian of Village Karakuba (later name Razdol'noye) in the south of Donets Basin (Donets Ridge, the Ukraine). Until the 1960^s palaeobotanists regarded *Callixylon* as a gymnospermous wood genus. But the epochal discovery by Beck (I960a, b) of organic connection *Archaeopteris*-leaves and woody branches of *Callixylon* has confirmed the appearance of true tree habit with picnoxylic axes in heterosporous – not seed, Late Devonian plants. There has been some debate over the taxonomical status of archaeopterids (Snigirevskaya 2000); *Archaeopteris* had no analogues indeed both among extant (Trivett 1993) and seemingly extinct plants too.

The main contributions into anatomy and taxonomy of *Callixylon* have been (chronologically): M.D. Zalessky, C.J. Hylander, M.G. Elkins and G.R. Wieland, C.A. Arnold, R. Kräusel and H. Weyland, H. Marcelle, C.B. Beck, L.C. Matten, V.G. Lepechina, J.E. Skog, Y. Lemoigne, A.L. Iurina, and N.S. Snigirevskaya, J. Galtier and B. Meyer-Berthaud, S. Chitaley, C. Cai, etc. Full bibliographies may be found in Arnold (1929, 1930, 1931), Beck (1952, 1953, 1962), Beck and Wight (1988), Lemoigne et al. (1983), Snigirevskaya (1984, 1988, 1995), Snigirevskaya and Lemoigne (1991), Meyer-Berthaud et al. (1997). Critical taxonomical study of *Callixylon* (Lemoigne et al. 1983) based both upon original and published data recognizes not more (and may be even less) than 8 species of the genus: *Callixylon arnoldii* Beck, *C. bristolense* Arnold, *C. brownii* (Read) Hoskins & Cross, *C. erianum* Arnold, *C. henkei* Kräusel & Weyland, *C. newberryi* (Dawson) Elkins & Wieland, *C. petryi* Beck, and *C. trifilievii* Zalessky. Names *C. timanicum* Zalessky ex Lemoigne et al., *C. velinense* Marcelle, *C. zalesskyi* Arnold, *C. whiteanum* Arnold are synonyms of the type-species name *C. trifilievii* Zalessky. *C. marshii* Hylander, *C. menthetense* Arnold, *C. schmidtii* Kräusel & Weyland have been considered as synonyms of *C. newberryi*. *C. clevelandensis* Chitaley (Chitaley 1988) from Ohio (USA) seems to be identicals *C. trifilievii* too, as groups of 6 pits around 1 or 10 pits around 2–3 in the center are common for the last species (Lemoigne et al. 1983). Obscure growth rings and wide interval of variability in the hight of rays are also observed in *C. trifilievii* and some other species (Lemoigne et al. 1983). Silicified wood named *Callixylon* cf. *clevelandensis* from the Late Devonian of Junggar Basin in China (Cai 1989) must be renamed *C. trifilievii* Zalessky.

Lepechina and Yatsenko-Khmelevsky (Lepechina 1972) have identified dispersed wood of callixyloid type presented only by fragments of secondary xylem without the primary tissues, as another more artificial genus *Desmoporoxylon*. In certain rate their concept of “parallel nomenclature” for wood (as for fossil Cenozoic leaves and pollen) has been excused by their desire to avoid the wrong phylogenetic conclusions. We suggest the choice of approaches to fossil wood taxonomy is the prerogative of every researcher.

LOCALITY IN ANDOMA MOUNTAIN

Andoma Mountain is a Federal Geological Monument ratified in 1978 (Budrin & Kotlukova 1985, Orlov 1998) has been considered among “extra conserved natural territories”. Andoma Mountain is in Vytegra District of Vologda Region on the shore of Onega Lake, 2 km to the south-west from Andoma River mouth, at 61°17′N, 36°20′E (Fig. 1). It is on

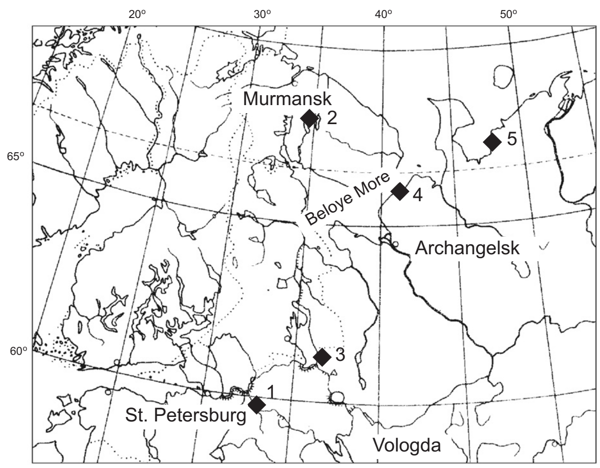

Fig. 1. Late Devonian sites of *Callixylon* in the north of the European Russia. **1** – The River Syass, **2** – Lovozero-Tunder, **3** – Andoma Mountain, **4** – Zimni Bereg, **5** – northern Timan

the peninsula about 30 km^2, up to 50 m high above Onega Lake level inside lowland swamp plains with abrupt slopes facing to Onega Lake. Intensively dislocated outcrops of Frasnian terrigenous rocks with about 150 m (visible thickness) exposed in shore cliffs (Fig. 2). The deposits are overlapped by hori-

Fig. 2. Andoma Mountain

zontally deposited, argillaceous soils and Quaternary moraine.

Devonian strata in Andoma Mountain have been divided into Gnevashevskaya and Olkovo Formations separated by disconformity. Deposits of both have been much dislocated tectonically seemingly during the ice-age.

The Gnevashevskaya Formation corresponds to Gauja – Sargaevo (undivided) Regional Substages of the Lower-Lowermost Middle Frasnian (Zhonsnitskaya & Kulikova 1990). The Gnevashevskaya Formation (about 65 m thick) is composed of layered clays (predominated) and red, brownish and green cross-bedding sands and sandstones. An abundance of fish remains have been recorded in the Andoma Locality (Petrov 1956). Remains of *Callixylon* wood presented in this paper have been collected in the same deposits.

The Olkovo Formation corresponds to Semiluki – Snezha Regional Substages of the upper part of the Middle – Lowermost Upper Frasnian (Zhonsnitskaya & Kulikova 1990). The Olkovo Formation (visible thickness about 80 m) is composed of red, yellow and rose-gray cross-bedded sands and very rarely of sandstones with layers of red or green clays and red argillites presented by "fish breccia" ("bone-bed"). According to Petrov (1956) ichthyofossils and rare bivalve-shells have been recorded in the Formation. *Callixylon* wood has been collected too, but most of them are not well preserved and hard to identify.

Fossil fish remains and silicified wood named erroneously *Nematophyton* on the grounds of their similar form, size and mode of preservation in the upper part of Gnevashevskaya Formation at Andoma Mountain were first published by Petrov (1956). True *Nematophyton* is known to be recorded from the Middle Devonian of the Main Devonian Field, collected by us in yellow sands and clays.

The new interest in problematic petrifactions appeared in 1996 during field trips of the second author (Snigirevsky) to the Andoma Mountain. Preliminary study some of them under scanning electron microscope (SEM) has shown the identity with *Callixylon trifilievii* Zalessky. Wood presented in this paper have been collected by S.M. Snigirevsky and his pupils A. Vassil'ev and K. Bystrov (V.A. Obrutschev Young Geologists Club in St. Petersburg Palace of Youth Creativity). Fig. 3 illustrates one of fossil wood from the Late Devonian of Andoma Mountain.

DESCRIPTION OF WOOD

Usually wood of *Callixylon trifilievii* Zalessky are irregularly silicified. Because of weathering there are annular structures on the shear surface, looking like growth rings. But surface zonality could be connected with process of impregnation of mineral solutions during fossilization. Further studies of this question are planned. Some silicified wood of *Callixylon* are hard and solid. But many wood are partly weathered and friable locally. They are easily broken during preparation and making of ground sections. At the same time this kind of wood does facilitate their weathered fragments for the SEM study. Usually anatomical structure is preserved well enough on shear surfaces. Study and definition of this

Photo by S.V. Kapitsky, 1997

Callixylon wood has been made only under the SEM.

About 10 petrified fragments of wood appear to be identical to *C. trifilievii* Zalessky. There are both large pieces of trunks (Fig. 3) up to 35 cm diameter and small ones presented only by fragments of secondary xylem without pith tissue or cortex. The most well preserved wood have been collected in the upper part of Gnevashevskaya Formation.

Fig. 3. Petrified wood of *Callixylon* in Andoma Mountain. Photo by V.E. Vassil'ev

A series of the SEM is presented in Fig. 4 and Pl. 1 figs 1 – 3a. Radial walls of tracheids and ray cells have shown that tangential pitting in wood are absent. Very long tracheids (about 1 mm long) with cohortoid radial pitting typical for *Callixylon,* and wood rays, are presented in Pl. 1 figs 1, 2. The type of pitting is generically characteristic for *Callixylon* and has been traditionally used for identification of Devonian wood of archaeopterids.

We could not demonstrate true growth rings in the over SEM but the exact difference of tracheids in their diameter have been certainly observed along radial and tangential directions. Individual groups of radial pitting in thin tracheids with 1-seriated pits and consist only of 3–5 pits, but more often pits are 2-seriated in a group (Pl. 1 fig. 1). Flower-like (star-like or "en margarite") disposition of pits inside an individual group is common too for wood *Callixylon trifilievii* Zalessky from Andoma Mountain (Pl. 1 fig. 2) as for the species in classical locality in Donets Ridge (Lemoigne et al. 1983). There are also some modifications of the type: more or less round group in the contour with 5, 6 pits around 1 in the center, oval one with 7–8 around central pit or 10 around 2 pits in the center (Ibid. Pl. 4 figs 2, 3). The first configuration has been lately observed by the first author of the presented paper also in cross-field of Late Permian *Araucarioxylon* sp. from Taimyr Peninsula in the Russian Arctic (Snigirevskaya & Gromyko 2000). The pit apertures in the radial pits are usually oblique.

There are the variation of rays in their height – 1 to 8 cells in the same plane and 1–25 (may be more) in different pieces of the same wood. Length of individual ray cells is exceeded the tracheids diameter in cross-fields 1.5–2 times (Pl. 1 figs 3, 3a). As 1–3 tracheids fit to 1 horizontal ray cell there are 1, 2 or 3 cross fields on the same cell. Radial walls of tracheids and ray cells (Pl. 1 figs 1, 2) have shown that tangential pitting in wood is absent. It has been confirmed by tangential sections (Fig. 4). There are 3–15 pits on the individual cross-fields (Pl. 1 fig. 3a). Size and form of cross-field pits are varied very much and sometimes depend of break planes. Wood parenchyma and any kind of resin canals or other secretory formations are known to be absent in *Callixylon*.

Fig. 4. *Callixylon trifilievii* Zalessky. Tangential view of tracheids (arrows – groups of radial pits) and two low wood rays incrusted by silica, × 600. SEM. Sample LP-22–10. Scale bar 10 μm

CONCLUSIONS

This new record of *Callixylon* in the palaeoflora of the north-west of Russia has increased our knowledge of distribution of archaeopterid forest formations over the land around sea on the Russian Platform during the Late Devonian. Remains of petrified *Callixylon* wood or *Archaeopteris* leaves in association with other plant remains were previously recorded too in the Late Devonian of some other localities of the region:

– Lovozero-Tunder in Kola Peninsula, Murmansk Region, where Krishtofovich (1937) described also *Psygmophyllum* cf. *williamsonii* Nathorst and *Rhacopteris* sp. in association with *Archaeopteris*;

– Northern Timan in Nenetz National District of Arkhangelsk Region: *Callixylon trifilievii* Zalessky (=*C. timanicum* Zalessky ex Lemoigne et al. 1983) and *Archaeopteris archetypus* Schmalhausen, *A. elschanica* Tschirkova-Zalesskaya, *A. fissilis* Schmalhausen, *A. laxa* (Hall) Nathorst, *A. macilenta* Lesquereux, *A. obtusa* Lesquereux, *A. sphenophyllifolia* Lesquereux, *Eddya sullivanensis* Beck (Snigirevsky 1997);

– Winter Shore (-Zimni Bereg) of the White Sea (Beloye More), Arkhangelsk Region, in kimberlite pipes where S.V. Meyen, A.L. Jurina and N.S. Snigirevskaya have recorded *Archaeopteris sibirica* Zalessky (younger synonym for *A. sphenophyllifolia*), *Callixylon* sp., *Xenocladia* cf. *medullosina* Arnold, and problematic remains identified as *Nematophytales* gen. indet.;

– The River Syass in St. Petersbourg Region – *Callixylon* sp. (Snigirevsky & Snigirevskaya 1997).

The new localities of fossil woody archaeopterids with associated brushwoods and herbaceous plants have indicated flora and vegetation over the land surrounding the Late Devonian sea basin where red terrigenous ("Old Red Sandstone") and carbonate rocks had been deposited inside Main Devonian Field (in current meaning).

So the spacious north-west area of the Russia being «the white spot» in relation to land palaeoflora on the Late Devonian palaeogeographical map up to the 90^s of the 20^{th} century appeared to be the area of wide development of archaeopterid forest formations inside the palaeotropical zone near 7°N in warm and humid climate (Scotese et al. 1979). The Baltic Shield territory in its eastern and southern borderlands (according to the modern position) was favorable for the wide invasion of the primary forests ecosystems.

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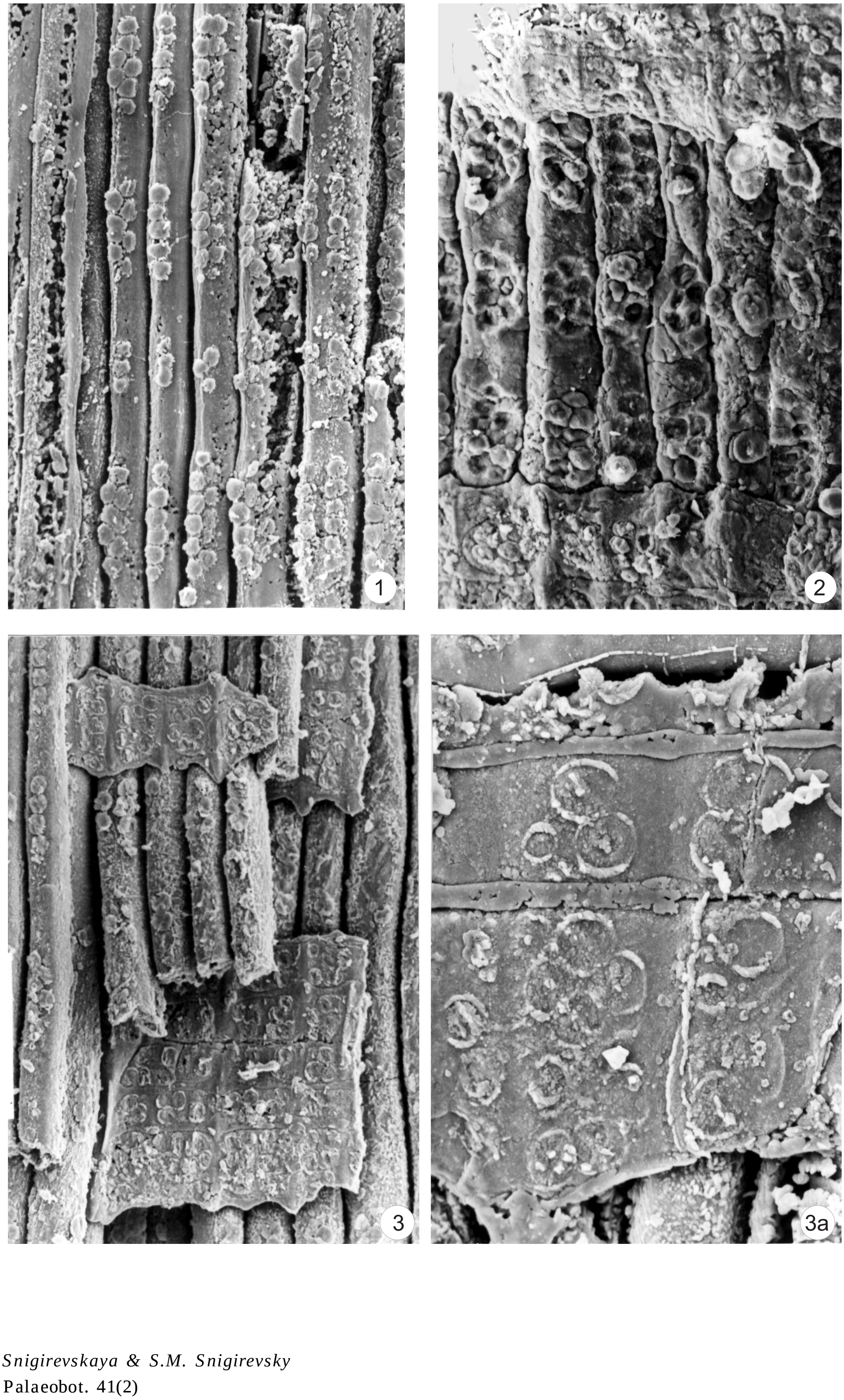
PLATE

Plate 1

Callixylon trifilievii Zalessky

1. Cohortoid (in groups) pits of tracheids in radial section, × 300. SEM, photo 2036. Sample LP-22–10
2. Flower-like disposition of pits in groups on radial wall, × 300. SEM, photo 2026. Sample LP-22–8
3. Radial view of weathered wood with wood rays, × 300. SEM, photo 2032. Sample LP-22–10

3a. Radial view of wood rays with round bordered pits (2–10) in cross-fields. × 1000. SEM, photo 2035. The same sample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