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Pinuxylon succiniferum (Goeppert) Kraeusel emend. Dolezych – amberized wood from Goeppert's type material restudied

With 2 plates, 7 figures and 1 table

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Kurzfassung

Dolezych, M.; Fischer, T. & Gröschke, A.: *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych – Reinterpretiertes Bernsteinholz von Goeppert's Typus Material

Originale des Bernsteinholzes von *Pinites succinifer* Goeppert 1883 aus dem samländischen Tertiär, welche aus dem berühmten Goeppert-Museum in Wrocław (Poland) stammen, wurden untersucht und als Morphotaxon *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych beschrieben. Die xylotomische Charakteristik dieser fossilen Art ist denen der Morphotaxa des Subgenus *Haploxylon* von *Pinus* L. vergleichbar. *P. succiniferum* ist dem fossilen Holz von *Pinuxylon parryoides* (Gothan) Kraeusel emend. Van der Burgh am ähnlichsten; jedoch nicht identisch. Der anatomische Vergleich von rezenten Hölzern mit dem bestimmten Fossil führt zur Gattung *Pinus* L. sowie zu dem Subgenus *Strobus* Lemmon. Das hier beschriebene *Pinus*-Holz besitzt anatomische Merkmale beider rezenten Sektionen *Parrya* Mayr und *Strobus* Little & Critchfield. Eine nähere Affinität konnte jedoch nicht festgestellt werden; es handelt sich um das Holz einer ausgestorbenen Kiefer. Der Lectotyp und Paratyp des Holzes von *Pinuxylon succiniferum* besteht aus fossilem Harz und Holz. Das fossile Harz wurde durch FTIR-Spektroskopie als die Bernsteinart Gedano-Succinit charakterisiert.

Schlüsselwörter: Fossiles Holz, Xylotomie, *Pinuxylon*, Gedano-Succinit, Infrarot-Spektroskopie, Paläogen, Samland

Abstract

Originals of amberized wood of *Pinites succinifer* Goeppert 1883 from the Samland (Sambian Peninsula) /Baltic Tertiary have been found in the famous Goeppert-museum in Wroclaw (Poland). They are investigated and the morphospecies *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych is established. This morphospecies is related to the subgenus *Haploxylon* of *Pinus*, and is most similar to the fossil species *Pinuxylon parryoides* (Gothan) Kraeusel emend. Van der Burgh; however, it is not identical. Comparison with wood of extant species indicates that the fossil represents the genus *Pinus* L., subgenus *Strobus* Lemmon. This here described pine wood combines anatomical features of both recent sections *Parrya* Mayr and *Strobus* Little & Critchfield. A more specific affinity could not be established, the described fossil is an extinct pine. The lectotype and paratype of

Pinuxylon succiniferum consists of fossil resin and wood. The fossil resin was characterized by means of FTIR spectroscopy as gedano-succinite.

Keywords: Fossil wood, Xylotomical investigations, *Pinuxylon*, Gedano-Succinite, Infrared Spectroscopy, Palaeogene, Sambian Peninsula

1 Introduction

In H. R. Goeppert-collection, being about 150 years old, of the Geology Museum of the University Wroclaw, Muzeum Geologicznego Uniwersytetu Wroławskiego, wood samples of the original material of *Pinites succinifer* Goeppert 1883 were found. This material consists of wood structures partially converted into tree resin and later fossilized into amber. From this arose the possibility of connecting the infrared spectra of the fossil resin with the corresponding taxonomy of the source tree.

The anatomy of this fossil wood was investigated and compared with other fossil and living wood. The investigations revealed an extinct species of *Pinus* L.: *Pinuxylon succiniferum* Goeppert (Kraeusel) emend. Dolezych.

The combination of chemical analyses (among others FTIR - spectroscopy) of the amber and xylotomic investigations allows the distinct identification of the botanical source. This approach is much more efficient than costly chemical series of tests with different recent and fossil resins, which usually permit only indirect and often ambiguous conclusions with regard to the botanical origin of a fossil resin. However, this approach requires occurrences of resins clearly associated with macrofossils.

2 Material

Two well preserved amberized wood remains were chosen for further analysis.

Sample numbers of the Muzeum Geologicznego Uniwersytetu Wroławskiego (MGUWr) in arabic numbers:

7423 p (1) = XVIII B a (1) (sample number original by Goeppert)

7434 p (1) = XXIX B (1) (sample number original by Goeppert).

For both samples the labels do not give the geological ages or any regional origin (Pieleńska 2001). According to Goeppert (Goeppert 1883, p. 28) the samples investigated by him originated from the Sambian Peninsula (formerly East Prussia, today: Kaliningrad Oblast, Russia) and additional one from Silesian deposits: "…Land- und Seebernstein der preussischen Küste, einmal nur weit entfernt in Schlesien bei Paschkerwitz, 2 Meilen von Breslau als Diluvialgeschiebe "[1].

[1] Two Miles NW from Wroclaw, Diluvium, card of the „Deutschen Reichs" by R. Lepsius, chart 21: Breslau; Paschkerwitz today: Pasikurowice.

Fig. 1: Label of the box from the König Salomo Apotheke, R. Michalke which belongs to the original material of *Pinites succinifer* Goeppert 1883, possibly handwritten by H. R. Goeppert (see Pielińska 2001, p. 115): "*Pinites succinifer*, Man sieht die großen Harzgefässe in den Markstrahlen, Original zu Abbild. Taf. …". Wood sample number No. 7423 p (1) [XVIII B a (1)].

Fig. 2: Fragment of amberized wood No. 7423 p (1), length of the specimen is approximately 1 cm; its cross section is 0,5 x 0,3 cm. Slide numbers: 130509/5, 140509/2, 180509/1.

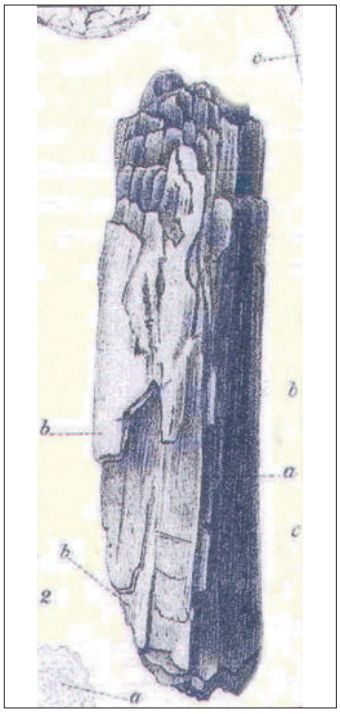


Fig. 3: The drawing of **original** material of *Pinites succinifer* Goeppert 1883 (Goeppert 1883, Plate 1, fig. 12; Length 7 cm; a wood, b amber remains), XXIX B (1).
Original text by Goeppert 1883, Plate I: "Taf. I. Das längste Stück des Bernsteinbaumes, *Pinites succinifer* Göp. & Ber., gegenwärtig im Besitz des Mineralogischen Museums zu Breslau. a. Holz, b. Bernsteinreste."

Fig. 4: Fragment of amberized wood No. 7434 p (1), length of this specimen is approximately 2 cm; cross section is 0,8 x 0,4 cm. The **original** material of *Pinites succinifer* Goeppert 1883 (Goeppert 1883, Taf. 1, Fig. 12). Slide numbers: 130509/1-4, 140509/1.

3 Methods

For xylotomical identification the amberized wood remains were cut into thin sections of 20-25 µm thickness and analysed with a Leica DM 5500 microscope, equipped with a digital camera (DFC 480).

The wood remains were identified by means of literature on recent and fossil wood as well as by comparison with reference collections of recent and fossil wood from the Laboratory of Palaeobotany and Palynology in Utrecht, the Natural History Museum at Berlin and from the private author's collection (Martina Dolezych). Descriptive terms are used according to current wood-anatomical terminology (e.g. Kräusel 1949, Greguss 1955, Van der Burgh 1973, Grosser 1977, IAWA 2004).

The Fourier Transform Infrared (FTIR) analyses were performed on a Thermo Nicolet Impact 410 spectrometer using the KBr pellet method. The spectral resolution was 2 cm^{-1} and 32 scans were averaged. 5,0 mg of powdered sample were thoroughly stirred in a mortar with 100 mg KBr and sintered into pellets. The samples were diluted with another portion of 100 mg KBr if necessary, the preparation of the pellets was repeated with an aliquot of 100 mg of the resulting mixture. Samples and KBr (Merck Uvasol for IR spectroscopy) were stored in a dessicator, a 100 mg KBr blank was used for IR background correction.

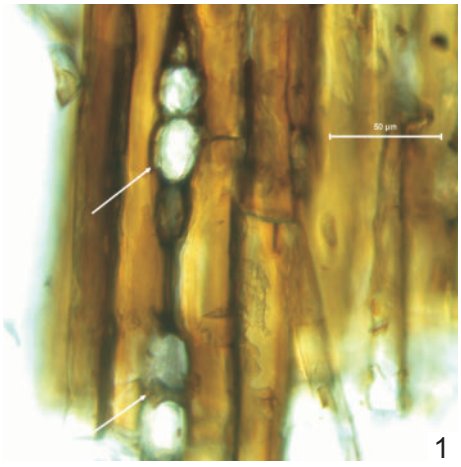
The spectra were recorded in the range from 400 cm^{-1} to 4000 cm^{-1}. The baselines were corrected manually using WinFIRST FTIR software (Mattson).

4 Xylotomical investigation

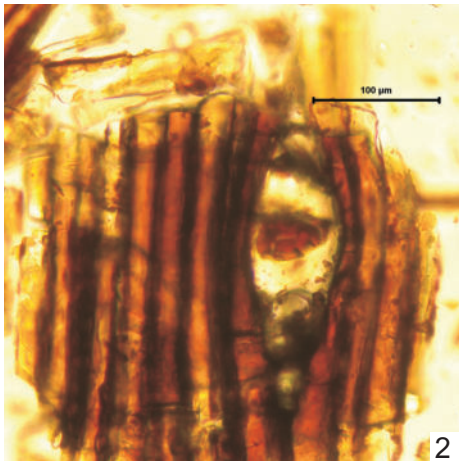
Conifers
Pinaceae L.
***Pinuxylon* Gothan 1905**
***Pinuxylon succiniferum* Goeppert (Kraeusel) emend. Dolezych**
Basionym: *Pinites succinifer* Goeppert in Goeppert & Berendt 1845 (p. 89; plate II, fig 1-8).

Synonymy:
Pinites succinifer Goeppert 1883 (p. 28-29; plate VIII, fig. 59-65; plate IX, fig. 66-70).
Pinus succinifera (Goeppert) Conwentz 1890 ex parte *Pinus succinifera* (Goeppert) Conwentz 1890 (p. 26-27; for example: Plates III, IV, V).
Pinuxylon succiniferum (Goeppert & Berendt) Gothan 1906 (in Heinhold, p. 118).
Pinuxylon succiniferum Goeppert nov. comb. Kraeusel 1949 without diagnosis (p. 135), see also Kräusel 1919 (p. 228, 249).
Pinus succinifera (Conwentz) emend. Schubert 1961 ex parte *Pinus succinifera* (Conwentz) emend. Schubert 1961 (p. 15, bark).

Lectotype:
Wood samples numbered No. 7434p-1 MGUWr, University of Wroclaw Geology Museum /Muzeum Geologicznego Uniwersytetu Wroławskiego (identical with the sample numbered XXIX B (1) of the Baltic amber collection attributed to H.R. Goeppert at the former Geology Institute at Breslau); here designated as lectotype.
Slides of the wood sample numbered No. 130509/1-4 (Plate I, 2-6; Plate II, 2-3, 5-6).



1



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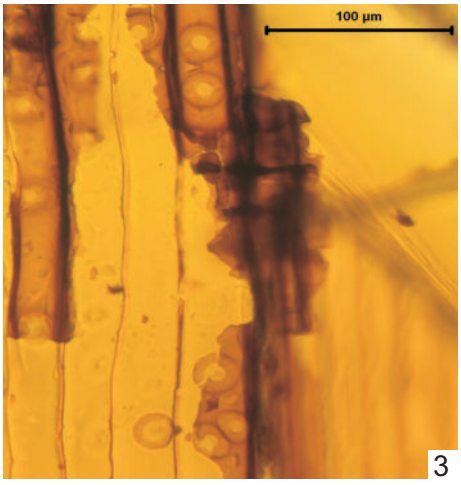

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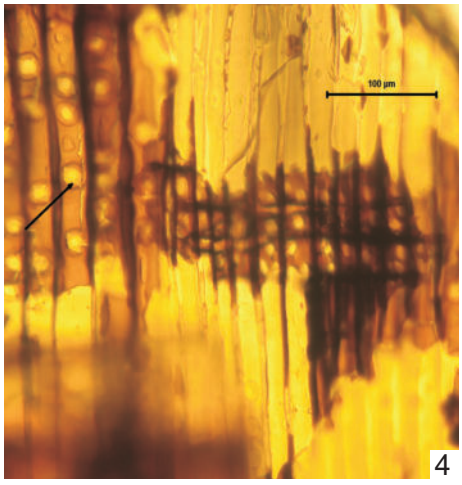

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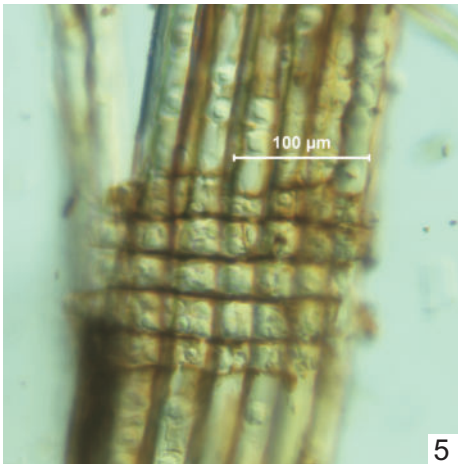

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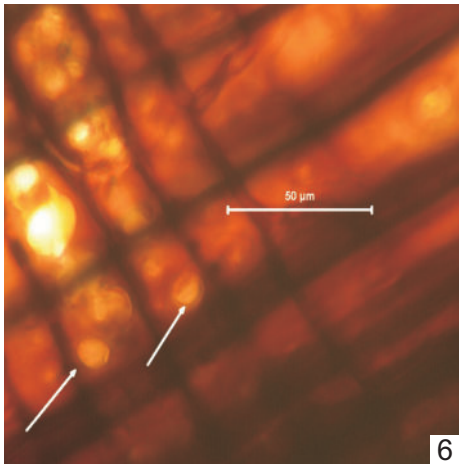

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Paratype:
Wood samples numbered No. 7423p-1 MGUWr, University of Wroclaw Geology /Muzeum Geologicznego Uniwersytetu Wroławskiego (identical with the sample numbered XVIII B a (1) of the Baltic amber collection attributed to H. R. Goeppert at the former Geology Institute at Breslau); here designated as paratype.
Slides of the wood sample numbered as No. 130509/5, 180509/1 (Plate I, 1; Plate II, 1, 4).
Locus typicus:
Sambian Peninsula/Palaeogene.

Repositorium:
Amberized wood specimens: University of Wroclaw Geology Museum /Muzeum Geologicznego Uniwersytetu Wroławskiego.
Slides of the amberized wood: Senckenberg Museum of Mineralogy and Geology at Dresden, Collection Dolezych/Tertiary of Europe.

Emended diagnosis:
Coniferous wood with distinct growth rings. Gradual transition between early and late wood; pits in radial walls of early wood tracheids occurring mostly in one vertical row, occasionally irregularly distributed, when in contact with each other usually flattened. Crassulae not present. Axial parenchyma absent. Rays heterocellular, mostly uniseriate, up to 10 cells high. Fusiform rays containing resin ducts, up to five cells wide and 20 cells high. Horizontal and tangential ray-walls thick and mostly smooth. Cross-field pits predominantly pinoid, two to four in one cross-field. Resin in tracheids and rays abundant.

Description of the wood: (Plates I-II; Figs. 5-6)
Growth rings: The early wood merges gradually into the late wood.
Tracheids: They are polygonal in cross shape. The dimensions are:

	Radial	Tangential	Wall-thickness
Early wood	25-40 µm	20-35 µm	3-8 µm
Late wood	15-20 µm	20-30 µm	7-10 µm.

Plate 1: Wood of *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych Original material from *Pinites succinifer* Goeppert 1883.

1. Tangential section showing tracheids and low rays (see arrows) of *P. succiniferum*, prep. 180509/1, paratype.

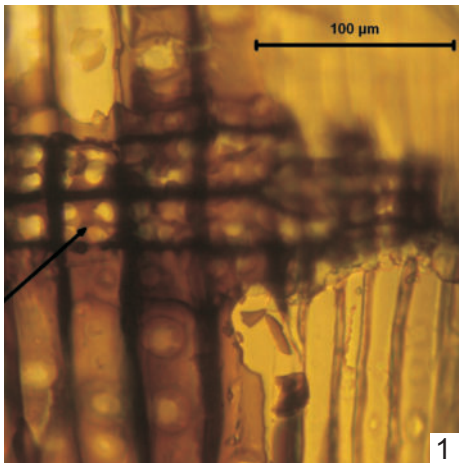
2. Tangential section showing a resin duct of *P. succiniferum*, prep. 130509/4, lectopype.

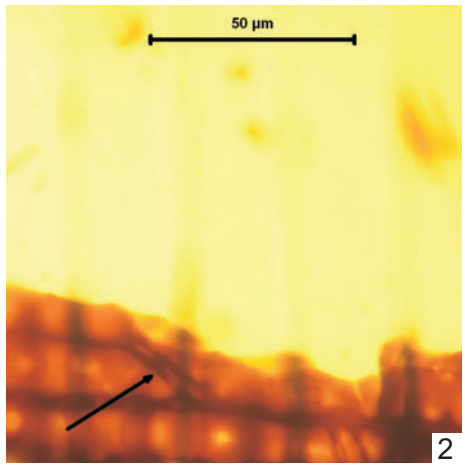
3. Radial section with radial tracheids and uniseriate bordered pits as well as in the middle part of the photo bordered pits, irregularly arranged of *P. succiniferum*, prep. 130509/1, lectotype.

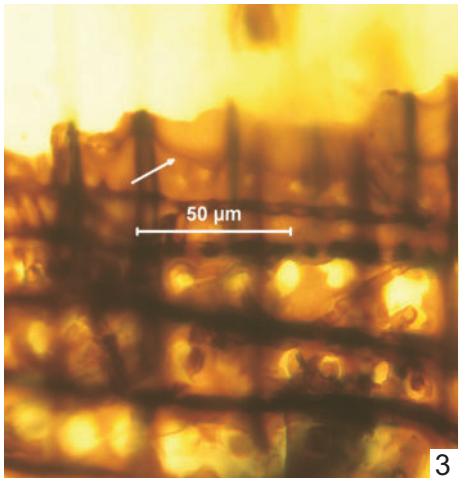
4. Radial section with radial tracheids, uniseriate bordered pits (see arrow) and a ray in the middle of the photo of *P. succiniferum*, prep. 130509/3, lectotype.

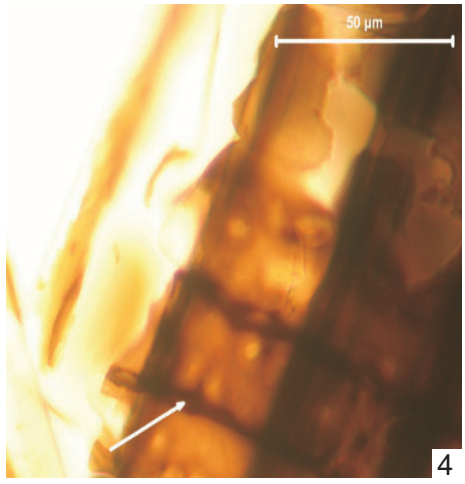
5. Radial section with radial tracheids, uniseriate bordered pits and a ray in the middle of the photo of *P. succiniferum*, prep. 130509/3, lectotype.

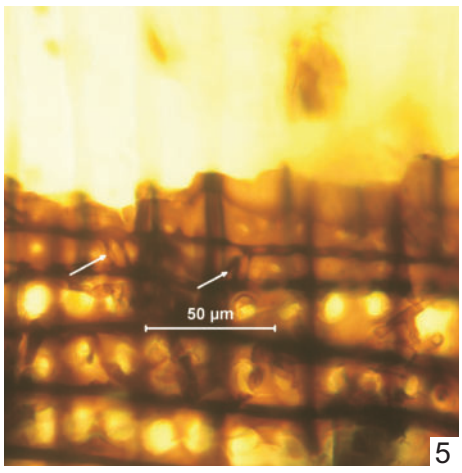
6. Radial section with a ray and pinoid pits in the cross-field (see arrows) of *P. succiniferum*, prep. 130509/2, lectotype.

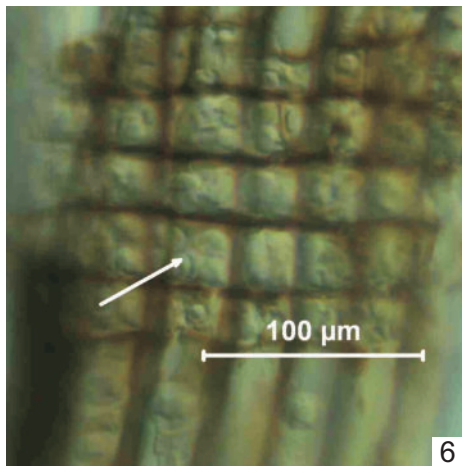

100 µm
1


50 µm
2


50 µm
3


50 µm
4


50 µm
5


100 µm
6

Bordered pits: Bordered pits in the radial walls of the tracheids occur predominantly in one vertical row (Plate I, 3-5; Plate II, 1; Fig. 5). Some of the pits are irregularly arranged and flattened when in contact (Plate I, 3; Fig. 5). Crassulae are not present. The diameter of the bordered pits sometimes reaches a size of up to 17 µm (Plate I, 3-5, 2; Fig. 5). The apertures of these pits are round. In the tangential walls of the tracheids pits are rare and, if present, round in shape, with a diameter of approximately 4 µm.

Axial parenchyma: Axial parenchyma absent.

Rays: The rays are uniseriate, heterocellular and up to 10 cells high (Plate I, 1; Fig. 6). The fusiform rays contain resin ducts and are up to five cells wide and 20 cells high (Plate I, 2; Fig. 6). The horizontal walls, with a thickness of 4-8 µm, are mostly thick and smooth, sometimes slightly pitted (Plate I, 4-6; Plate II, 1-3, 5-6; Fig. 5). The tangential walls are smooth and almost as thick as the horizontal walls (Fig. 5). The cells reach a height of up to 35 µm (Plate I, 4-6; Plate II 1-6). Indentures are absent. In the cross-fields two to four pinoid pits are present (Plate I, 4-6; Plate II, 1, 3, 5-6; Fig. 5); the diameter of these pits is 4-12 µm. Ray tracheids occur at the upper and lower margins of the ray. The walls are mostly smooth (Plate II, 3; Fig. 5), occasionally showing dentations (Hudson-Gradation 2-4, Hudson 1960) (Plate II, 4; Fig. 5). Ray cell walls with helical thickenings resembling fine dentations have been observed (Plate II, 5; Fig. 5). The diameter of the bordered pits is about 7 µm. The bordered pits of the ray tracheids are characterized as a *Picea*-type 1 (Plate II, 2; Fig. 5) according to Bartholin in Anagnost et al. (1994, p. 175)

Resin ducts: Vertical and horizontal resin ducts are surrounded by thick-walled tissue (Fig. 6). The walls of the epithelium cells are thinner than the walls of the surrounding tissue. These cells are sometimes collapsed (Plate I, 2; Fig. 6). The number of epithelium cells is about 12. The diameter of the horizontal resin ducts ranges between 40 and 80 µm; that of the vertical ones reaches up to 220 µm.

Resin: Resin, honey-yellow and sepia-brown in color, abundant, especially in tracheids and rays (Plate I-II).

Plate II: Wood of *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych Original material from *Pinites succinifer* Goeppert 1883.

1. Radial section with radial tracheids, a ray and four cross-field pits in one cross-field (see arrow) of *P. succiniferum*, prep. 130509/5, paratype.

2. Radial section with a ray, a ray tracheid and the *Picea*-type 1 of the bordered pits of the ray tracheid (see arrow) of *P. succiniferum*, prep. 130509/2, lectotype.

3. Radial section with a ray, a ray tracheid and a smooth ray tracheid wall (see arrow) of *P. succiniferum*, prep. 130509/2, lectotype.

4. Radial section with a ray, a ray tracheid and a dentate ray tracheid wall (see arrow) of *P. succiniferum*, prep. 130509/5, paratype.

5. Radial section with a ray and cell walls with helical thickenings in the ray tracheid (see arrows) of *P. succiniferum*, prep. 130509/2, lectotype.

6. Radial section with a ray and three to four pinoid cross-field pits in one cross-field (see arrow) of *P. succiniferum*, prep. 130509/3, lectotype.

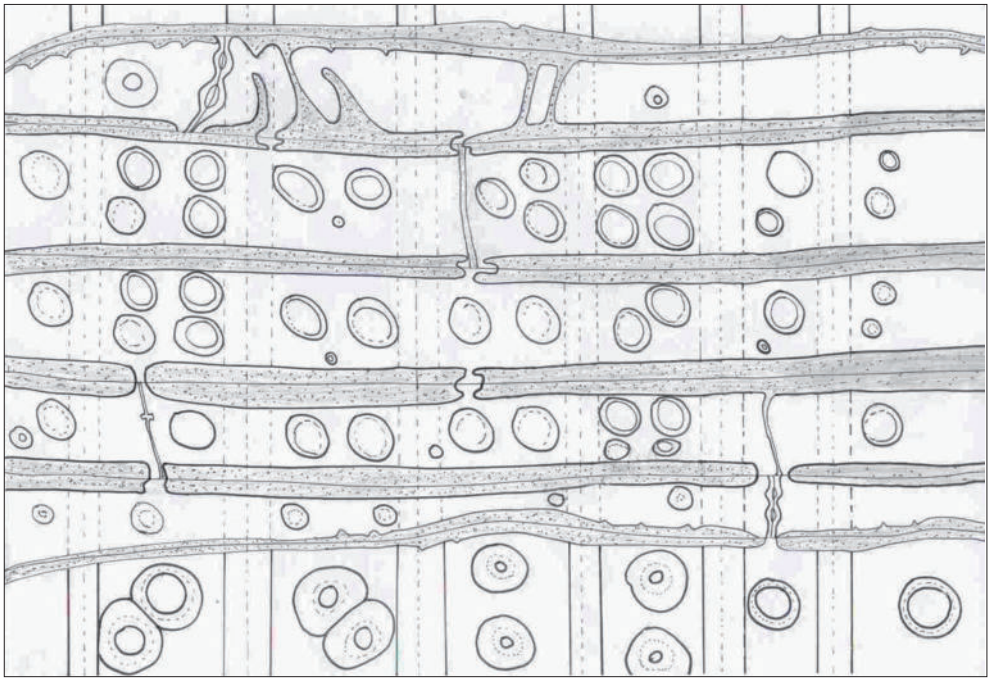


Fig. 5: Radial section of *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych with ray and tracheids, cross-field pits, radial bordered pits and ray tracheids, x 400.

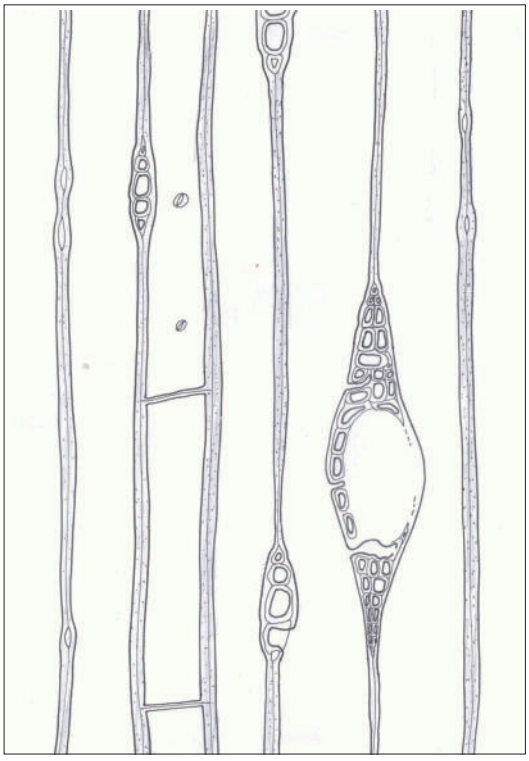


Fig. 6: Tangential section of *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych with tracheids, rays and a resin duct, x 400.

Identification:

The amberized wood with its characteristic features of horizontal and vertical resin ducts clearly belongs to the Pinaceae.

Based on a coniferous wood structure, the presence of abietoid pitting radial tracheid wall, horizontal and vertical normal ducts, ray tracheids, mostly pinoid cross-field pits and thin-walled surrounding tissue of the resin ducts, this wood is placed in the morphogenus *Pinuxylon* as defined by Gothan (1905, p. 102).

Following the identification key by Kräusel (1949, p. 163) and under consideration of the predominance of pinoid cross-field pits as well as the horizontal and vertical resin ducts and the generally smooth horizontal and tangential rays, this wood belongs to *Pinuxylon*. However, the wood differs from the *Pinuxylon*-species listed in Kräusel´s key, hitherto identified as *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych. The xylotomist M. Dolezych proposes to use the epitheton "*succiniferum"* based on the basionym *Pinites succinifer* Goeppert in Goeppert & Berendt 1845 of this redescribed morphospecies from the original material of this Baltic amber.

In contrast to our observations Goeppert did not mention ray tracheids and halos in the cross-field pits on the original material *Pinites succinifer* Goeppert (Goeppert & Menge 1883, p. 28-29; plate VIII, fig. 59-65; plate IX, fig. 66-70). The lack of the ray tracheids in his description is possibly due to inexperience concerning this anatomical feature in those times. Furthermore, resin ducts worthy of drawing are only seen in the amber tree *Pinites radiosus* Goeppert (Goeppert 1883, plate XII, fig. 86).

Similarities with woods from Kräusel's list exist with respect to *Pinuxylon baumanii* Read, *P. parryoides* (Gothan) Kraeusel and *P. succiniferum* (Goeppert) Kraeusel (Kräusel 1949, p. 163). The new wood may be distinguished from the first one mentioned by having also slightly dentate ray tracheid walls, from the second one by having clearly greater pinoid pits and from the last one by having slightly dentate ray tracheids as well as pinoid cross-field pits and from all those described above, the wood differs in having helical thickenings of the ray tracheids.

Pinuxylon parryoides was later emended by Van der Burgh (1964, p. 254-259; 1973, p. 104-106). He described this taxon in respect to the ray tracheids with: „mit vereinzelten, winzigen, oft kaum wahrnehmbaren Zacken". It means he included smooth as well as slightly dentate ray tracheids (about Hudson-Gradation 2, Hudson 1960) in his taxa. Thus *Pinuxylon baumanii* is a synonym of this emended *Pinuxylon*-morphospecies. Also the basionym of *Pinuxylon parryoides*, *Pinus parryoides* Gothan (1911, p. 520–528), is described with smooth cell walls of the ray tracheids: „…Quertracheiden ohne jede Zackenbildung…" (Gothan 1911, p. 521). This configuration is also to be seen in the drawing by Gothan (1911, p. 522, fig. 2). The features of the investigated wood suggest a relationship with the *Pinuxylon parryoides* (Gothan) Kraeusel emend. Van der Burgh, known from the Rhenish and Lusatian brown coal (Van der Burgh 1964, 1973; Dolezych 2005, Dolezych & Schneider 2007).

A very similar wood, a *Pinuxylon* cf. *parryoides* (Gothan) Kraeusel emend. Van der Burgh, was discovered by Gottwald (1966, p. 78-79) in the Eocene Helmstedt Brown Coal. It is interesting to note that Gottwald observed abundant inclusions, perhaps of resin, in the tracheid walls: "…braune, blasige oder tropfenartige Anfüllungen häufig."

Another fossil from the European Tertiary which is similar to the described fossil wood is *Pinuxylon tarnocziense* (Tuzśon) Greguss. It is known from the Hungarian (Tuzśon 1901; Greguss 1954, 1967), from the Rhenish (Van der Burgh 1973) as well as from the Lusatian Tertiary (Dolezych & Schneider 2006). In contrast to the fossil described above

the horizontal and tangential ray walls are clearly dentate and they have fenestriform cross-field pits. It is suggested that this fossil has affinity to the recent section *Strobus* Little & Critchfield.

A *Pinuxylon* sp. with similarities to our Samland wood was described by Meijer (2000, p. 31; Plate VI, fig. 28-31) from the Late Cretaceous Aachen Formation, but this fossil differs by having only two pinoid cross-field pits in the cross-field. But a few more cross-field pits are to be seen in his fig. 31 (Plate VI). And interestingly, Meijer found an affinity to the recent section *Parrya* Mayr for his fossil remains. This Cretaceous wood is close to our described amber wood.

History:

The morphogenus *Pinites* was established by Lindley & Hutton 1831 for cordaites with the holotype *Pinites brandlingi* Lindley & Hutton 1831 from the Carboniferous of Great Britain (in Andrews 1970, p. 163).

Later the morphogenus *Pinites* was newly described by Goeppert & Berendt (1845, p. 89) and applied for amber conifers and a more detailed diagnosis was given by Goeppert (1883, p. 27). These authors used the name *Pinites* for a group of plants completely different from the *Pinites* of Lindley & Hutton. This morphogenus *Pinites* described amber conifers only, and this is a double determination. Because it is important for amber wood and has been used about 150 years, we accept this taxon. But for understanding the amber descriptions it must be pointed out that the *Pinites* of Goeppert contents fossils with an affinity to various recent genera, for example to *Pinus*, *Picea* and also to taxa of the Cupressaceae *s. l.* (For example: *Pinites gypsaceus* Goeppert is comparable in respect to its anatomical features with the extant *Sequoia*.). Goeppert (1883) described six different morphospecies from the Baltic amber wood: *Pinites succinifer*, *Pinites Mengeanus, Pinites stroboides, Pinites radiosus, Pinites anomalus* and *Physematopitys succinea*. He noted botanical affinities of these fossils to the recent genera *Pinus, Picea* and *Taxus*.

The wood described above is the original material of *Pinites succinifer* Goeppert 1883 (p. 28-29; Plate VIII, fig. 59-65; Plate IX, fig. 66-70). In contrast to the abundant occurrences of *Pinites stroboides* Goeppert 1883 in the Baltic Tertiary Goeppert (1883, p. 28) noted that *Pinites succinifer* Goeppert was a rare element of the Baltic amber forest.

Later Conwentz (1890, p. 26-27) combined all the *Pinites*–morphospecies of the Baltic amber investigated by Goeppert in a collective taxon: *Pinus succinifera* (Goeppert) Conwentz. Whether this is correct, can only be confirmed with certainty by an investigation of the original material of the morphospecies mentioned. Affinities to these morphospecies were found in the living genera *Pinus* and *Picea* (*Pinus s. l.* in former times).

Kräusel (1949 p. 135) gave two taxa from the Baltic amber as described by Goeppert: *Pinuxylon succiniferum* (Goeppert) nov. comb. Kraeusel and *Pinuxylon stroboides* (Goeppert) nov. comb. Kraeusel. But in the description of the two taxa Kräusel confused the anatomical features of both taxa and there must be some mistake. It had to be because he had already recognized in his earlier paper (Kräusel 1919 p. 225, 249) the following affinities: for *Pinus succinifera* (Goeppert) Conwentz ex parte (*Pinites succinifer* Goeppert) to the section *Parrya* Mayr as well as to the section *Balfouria* Mayr and for *Pinus succinifera* (Goeppert) Conwentz ex parte (*Pinites stroboides* Goeppert) he suggested an affinity to the section *Strobus* Mayr as well as to the section *Cembra* Mayr. No diagnoses were given for the combined taxa.

Schubert (1961) described *Pinus succinifera* (Conwentz) Goeppert as a collective species for *Pinus succinifera* remains on the basis of anatomical investigation of its bark (Schubert 1961). No diagnosis was given, affinities for these barks being found only in recent *Pinus*-bark; therefore, no official emendation was possible and thus his emendation is illegitimate. It is just a discussion of Conwentz´ and Kräusel´s ideas. Schubert (1961, p. 15) excluded *Picea* as a possible affinity for the amber trees.

Affinity:

Based on its structure the wood is comparable to that of species of *Pinus* L. There is however no close similarity with the wood of any living species of the genus *Pinus* (see Greguss 1955). The described morphospecies represents an extinct wood. This fossil wood is characterized by a combination of ancient wood anatomical features like thick-walled ray parenchyma, smooth and slightly pitted cell walls of the rays and almost smooth ray tracheid walls with the presence of slight dentations and with additional spiral thickenings. The xylotomical features lead in respect to the key by Van der Burgh (1973, p. 100) for the extant genus *Pinus* to the haploxyl section *Parrya* Mayr as well as to the section *Strobus* Little & Critchfield. To the first one section mentioned belong for example Asian species like *Pinus bungeana* Zuccarini and *Pinus krempfii* Lecomte (Ickert-Bond 2000), the Mexican *Pinus nelsonii* Shaw, as well as the North American taxa *Pinus aristata* Engelmann, *Pinus balfouriana* Jeffrey ex A. Murray (Flora of North America Editorial Committee 1993) (Van der Burgh 1973, p. 81-88).

To the section *Strobus* belongs species like *Pinus strobus* L., *Pinus lambertina* Douglas, *Pinus peuce* Grisebach, *Pinus parviflora* Siebold & Zuccarini (Van der Burgh 1973, p. 90).

It is important to note that dentations with spiral thickenings, as observed in the Samland fossil (Plate II, 5; Fig. 6) usually occur in *Picea* A. Dietrich, *Larix* Miller, *Cathaya* Chun & Kuang and *Pseudotsuga* Carrière (IAWA 2004, p.43, fig. 40; here *Picea abies* L.).

It is near to consider the Samland fossil to be an ancient relict that in former times (Palaeogene and earlier) combined anatomical features of both sections *Parrya* and *Strobus*. This fits very well to the investigations by Millar (1993) who observed that most of the Creataceous *Pinus* species have combinations of features not to be seen in extant *Pinus*. In these ancient times there existed many lineages of *Pinus* which could be related to an ancestral type. The impact of the Eocene with its important climatic, tectonic, and biogeographical changes causes the splitting of the genus *Pinus*. Additionally, Millar (1998) gave for the section *Parrya* a basal systematic position in the system of *Pinus* L. A second agreement exists with the evolutionary line studied by Bailey (1910, p. 292-293) who noted that the evolutionary development of *Pinus* is characterized by the "…transition from the thick-walled rays cells …of the ancestral type to thin-walled cells…" This transition is partially also to be observed in the description of the amber wood. Also this material belongs to an ancestral type of *Pinus*.

Taking into consideration modern moleculargenetic investigations the Asian species of the section *Parrya* Mayr are united with the section *Strobus* Little & Critchfield to a new section called *Quinquefoliae* (Gernandt et al. 2005). Furthermore the heterogeneous section *Parrya* is now assigned to the haploxyl subgenus *Strobus* Lemmon (Liston et al. 1999). These authors pointed out that the paraphyletic section *Parrya* is a basal group within the Subgenus *Strobus*.

5 Infrared Spectroscopy

Typical IR spectra of Baltic amber are characterized by strong absorptions caused by aliphatic C-H stretching vibrations, by absorptions being attributed to C=O groups as occurring in esters, ketones and carboxylic acids as well as by various absorption bands caused by C-O stretching vibrations. The so-called „Baltic shoulder“ in the 1160 - 1250 cm^{-1} range and the absence of any aromatic structures distinguishes Baltic amber from most other types of fossil resins (Lühr 2004, Beck 1986). IR bands and bonding assignments of the specimen investigated in this study are listed in Table 1. The spectra are depicted in Fig. 7. Stout et al. (1995) and Kosmowska-Ceranowicz (1999) reported IR spectra for succinite, gedanite and for gedano-succinite. The two last mentioned authors pointed out, that succinite and gedano-succinite are distinguishable by infrared spectroscopy although they share their major spectral characteristics. Succinite was characterized by a more prominent absorption caused by the C=O of the ester function around 1740 cm^{-1} in comparison with the ketone/carboxylic acid signal at approximately 1710 cm^{-1}, whereas the spectra of gedanite showed a different behavior. In the IR spectra of the ‘transitional type’ - gedano-succinite - both signals were of equal intensity. The „Baltic shoulder“ was observed in succinite only, whereas the spectra of gedanite had a distinct absorption peak at approximately 1235 cm^{-1}, which was equivalent or even exceeded the intensity of the peak at 1160 cm^{-1}. Again, the spectra of gedano-succinite had intermediate properties, showing a distinct peak at approximately 1235 cm^{-1}, which was less intense than the peak at 1160 cm^{-1}. In addition, gedanite was characterized by a weak signal at 980 cm^{-1}, where succinite and gedano-succinite had strong absorption peaks which almost equaled the signal at 1018 cm^{-1} (Stout et al. 1995, Kosmowska-Ceranowicz 1999).

In both spectra of this study the signals at 1735 cm^{-1} (ester C=O) and at 1713 cm^{-1} (ketone/carboxylic acid) showed equal intensity. The signals at 980 cm^{-1} were intense in both spectra, whereas the signals at 1237 cm^{-1} were prominent but less intense than at 1160 cm^{-1} (Fig. 7). Summarizing these findings it can be concluded that the two specimens investigated in this study by means of IR spectroscopy can be classified as gedano-succinite.

Tab 1: IR signals and band assignments (types of vibrations) of the samples XVIII B a (1) and XXIX B (1). The location of IR bands was identical for both samples, individual peak ratios are discussed in the text.

Wavenumber [cm^{-1}]	Band assignment
3436	-OH stretch (water, hydroxyl)
3077	=CH stretch (olefine)
2964	asymmetric $-CH_3$ stretch
2929	asymmetric $-CH_2$ stretch
2870	symmetric $-CH_3$ stretch
2850	symmetric $-CH_2$ stretch
1735	C=O stretch (ester)
1713	C=O stretch (ketones, carbonic acids)
1643	-OH bend (water) -C=C-
1456	asymmetric $-CH_3$ bend
1384	symmetric $-CH_3$ bend
1376	
1237	C-O stretch
1160	
1018	
980	CH rock
888	$=CH_2$ (vinylidene)

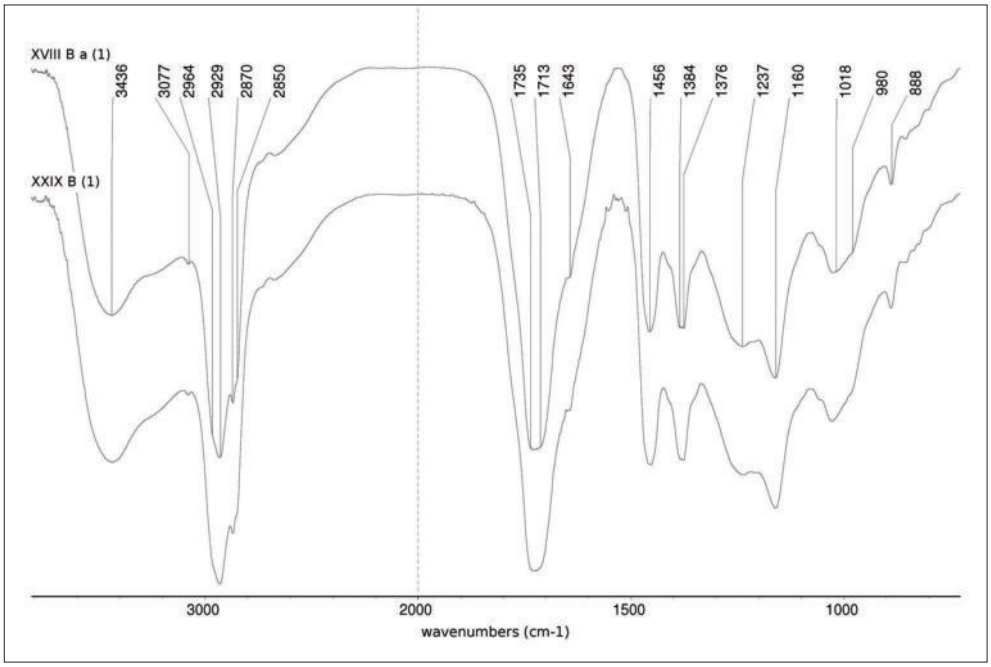


Fig. 7: Infrared spectra of the amberized wood of *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych.

6 Conclusions

The taxon *Pinuxylon succiniferum* (Goeppert) Kraeusel emend. Dolezych is newly described and emended based on the original material of *Pinites succinifer* Goeppert 1883 from the Paleogene of Sambian Peninsula. The corresponding fossil resin is characterised by means of FTIR spectroscopy as gedano-succinite.

This extinct *Pinus*-wood shows affinity to the recent section *Parrya* Mayr as well as to the section *Strobus* Little & Critchfield, of the subgenus *Strobus* Lemmon.

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8 References

Andrews, H. N. (1970): Index of Generic Names of Fossil Plants, 1820-1965. – Bull. U. S. Geol. Surv. 1300, Washington.

Anagnost, S. E., Meyer, R. W. & DeZeeuw, C. (1994): Confirmation and Significance of Bartholin´s method for the identification of the wood of *Picea* and *Larix*. – Department of Wood Products Engineering, SUNY College of Environmental Science and Forestry, New York 13210, USA; Syracuse.

Bailey, I. R. (1910): Anatomical characters in the evolution of *Pinus*. – The American Naturalist **44**: 284-293.

Beck, C. W. (1986): Spectroscopic Investigations of Amber. – Applied Spectroscopy Reviews **22** (1): 57-110.

Conwentz, H. (1890): Monographie der baltischen Bernsteinbäume. – Commissionsverl. von Wilh. Engelmann in Leipzig , Danzig (151 pp).

Dolezych, M. (2005): Koniferenhölzer im Lausitzer Flöz und ihre ökologische Position. – LLP Contributions Series No. **19**: 1-339, Utrecht.

Dolezych, M. & Schneider, W. (2006): Xylotomie und feinstratigraphisch-fazielle Zuordnung von inkohlten Hölzern und dispersen Kutikulen aus dem 2. Lausitzer Flöz (Miozän) im Tagebau Welzow. – Zeitschrift für geologische Wissenschaften **34**: 165-259.

Dolezych, M. & Schneider, W. (2007): Taxonomie und Taphonomie von Braunkohlenhölzern und Cuticulae dispersae von Koniferen im 2. Lausitzer Flözhorizont (Miozän) des Senftenberger Reviers. – Palaeontographica B **276**: 1-95.

Flora of North America Editorial Committee (1993): Flora of North America, North of Mexico, vol. 2, Pteridophytes and Gymnosperms. – Oxford Univ. Press, New York.

Gernandt, D. S., Lopez, G. G., Garcia S. O. & Liston, A. (2005): Phylogeny and classification of *Pinus*. – Taxon **54**: 29-42.

Goeppert, H. R. & Berendt, G. C. (1845): Der Bernstein und die in ihm befindlichen Pflanzenreste der

Vorwelt. – In: Berendt, G. C. (Ed.): Die im Bernstein befindlichen organischen Reste der Vorwelt. – Berlin (126 pp.).

Goeppert, H. R. & Menge, A. (1883): Die Flora des Bernsteins und ihre Beziehungen zur Flora der Tertiärformation und der Gegenwart. 1. Bd.: Von den Bernstein – Coniferen, insbesondere auch in ihren Beziehungen zu den Coniferen der Gegenwart. – Commissionsverl. von Wilh. Engelmann in Leipzig, Danzig (63 pp.).

Gothan, W. (1905): Zur Anatomie lebender und fossiler Gymnospermen Hölzer. – Abh. Kgl. Preuß. Geol. Landesanst., Neue Folge **44**: 1-108.

Gothan, W. (1911): Über Braunkohlenhölzer des rheinischen Tertiärs. – Jahrb. Kgl. Preuß. Geol. Landesanst. **30**: 516-532.

Gottwald, H. (1966): Eozäne Hölzer aus der Braunkohle von Helmstedt. – Palaeontographica B **119**: 76-93.

Gottwald, H. (1992): Hölzer aus marinen Sanden des oberen Eozäns von Helmstedt. – Palaeontographica B **225**: 27-103.

Greguss, P. (1954): Wood remains from the Lower Miocene of Ipolitarnoc. - Földt. Közl. **84**: 91-110, Budapest.

Greguss, P. (1955): Identification of living gymnosperms on the basis of xylotomy. – Akad. Kiadó, Budapest (308 pp.).

Greguss, P. (1967): Fossil Gymnosperm Woods in Hungary from Permian to Pliocene. – Akad. Kiadó, Budapest (136 pp.).

Grosser, D. (1977): Die Hölzer Mitteleuropas. Ein mikrophotographischer Lehratlas. – Springer-Verlag (208 pp.).

Heinhold, M. (1906): Über die Entstehung des Pyropossites. – Jahrb. Preuß. Geol. Landesanst. **27**: 114-158.

Hudson, R. H. (1960). The Anatomy of the genus *Pinus* in relation to its classification. – J. Inst. Wood Sci. **6**: 26-46.

Ickert-Bond, S. M. (2000): Cuticle micromorphology of *Pinus krempfii* Lecomte (Pinaceae) and additional species from Southeast Asia. – Int. J. Plant Sci. **161**: 301-317.

IAWA Committee (2004): H. G. Richter, D. Grosser, I. Heinz & P. E. Gasson (eds.), IAWA list of microscopic features for softwood identification. – IAWA Journal **25**: 1-70.

Kosmowska-Ceranowicz, B. (1999): Succinite and some other fossil resins in Poland and Europe (deposits, finds, features and differences in IRS). – Estudios del Museo de Ciencias Naturales de Alava **14**: 73-117.

Kräusel, R. (1919): Die fossilen Koniferenhölzer unter Ausschluß von *Araucarioxylon* Kraus. Versuch einer monographischen Darstellung. – Palaeontographica B **62**: 185-280.

Kräusel, R. (1949): Die fossilen Koniferenhölzer (unter Ausschluss von *Araucarioxylon* Kraus). – Palaeontographica B **89**: 83-203.

Lindley, J. & Hutton, W. (1831). Foss. Fl. Gr. – Brit. **1**: XXXIX.

Liston, A., Robinson, W. A., Pinero, D. & Alvarez-Buylla, E. R. (1999): Phylogenetics of *Pinus* (Pinaceae). Based on Nuclear Ribosomal DNA Internal Transcribed Spacer Region Sequences. – Molecular Phylogenetics and Evolution **11**: 95-109.

Lühr, Ch. (2004): Charakterisierung und Klassifikation von fossilen Harzen. – 244 pp., Dissertation, Universität Duisburg-Essen.

Meijer, J.F. J. (2000): Fossil woods from the Late Cretaceous Aachen Formation. – Rev. Palaeobot. Palynol. **112**: 297-336.

Millar, C. I. (1993): Impact of the Eocene on the evolution of *Pinus* L. – Annals of the Missouri Botanical Garden **80**: 71-498.

Millar, C. I. (1998): Early evolution of Pines. – In: D. M. Richardson (ed.), Ecology and biogeography of *Pinus*. – Cambridge University Press: 69-91.

Pielińska, A. (2001): Fragment bursztynowej kolekcji H. R. Goepperta w zbiorach Muzeum Geologicznego Uniwersytetu Wroławskiego. – Prace Muzeum Ziemi **46**: 107-155.

Schubert, K. (1961): Neue Untersuchungen über Bau und Leben der Bernsteinkiefern [*Pinus succinifera* (Conw.) emend.]. – Beih. Geol. Jb. **45**: 1-149.

Stout, E. C., Beck, C. W. & Kosmowska-Ceranowicz, B. (1995): Gedanite and Gedano-Succinite. – ACS Symposium Series **61**: 130-148.

Tuzśon, D. J. (1901): Der fossile Baumstamm bei Tarnócz (*Pinus tarnocziensis*). – Természetrajzi Füzetek **24**: 273-316, Budapest.

Van der Burgh, J. (1964): Hölzer der niederrheinischen Braunkohlenformation. 1. Hölzer der Braunkohlengrube „Anna" zu Haanrade (Niederl. Limburg). – Acta Bot. Neerl. **13**: 250-301.

Van der Burgh, J. (1973): Hölzer der niederrheinischen Braunkohlenformation. 2. Hölzer der Braunkohlengruben „Maria Theresia" zu Herzogenrath, „Zukunft West" zu Eschweiler und „Victor" (Zülpich-Mitte) zu Zülpich. Nebst einer systematisch-anatomischen Bearbeitung der Gattung *Pinus* L. – Rev. Palaeobot. Palynol. **15**: 73-275.

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