

# A palm-tree and *Sciadopitys* swamp-forest from the Neogene of Bresse (eastern France)

Marc Philippe<sup>a,b,\*</sup>, Henriette Méon<sup>b</sup>, Georges Lambert<sup>c</sup>, Boglarka Erdei<sup>d</sup>, Frédéric Thevenard<sup>a,b</sup>, Bernard Gomez<sup>a</sup>

<sup>a</sup> Université Lyon-1, 7, rue Dubois, 69622 Villeurbanne cedex, France

<sup>b</sup> UMR 5125 du CNRS, 7, rue Dubois, 69622 Villeurbanne cedex, France

<sup>c</sup> Laboratoire de chrono-écologie, université de Franche-Comté, route de Gray, 25000 Besançon, France

<sup>d</sup> Palaeobotany, Hungarian Natural History Museum, 1476 Budapest Pf. 222, Hungary

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**Abstract** – During the Tertiary, a thick sedimentary sequence was accumulated in the Bresse Basin, including some lignite that was locally excavated. Although the palynology of this lignite is relatively well known, the fossil plant macroremains were only poorly studied. Well-preserved material from a new Upper Pliocene (Reuverian) outcrop is reported herein. It allows for palaeoecological and biogeographical reinterpretation. The flora, which includes palm-trees and umbrella pine, is interpreted as a ‘Sequoia-Moor’, i.e. an acidophilic swamp-forest type that had never been evidenced from both micro- and macroremains in France. **To cite this article:** M. Philippe et al., C. R. Palevol 1 (2002) 221–225. © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

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**Résumé** – Une forêt marécageuse à *Sciadopitys* et palmiers dans le Néogène bressan. Le bassin de la Bresse a piégé au cours du Tertiaire une grande quantité de sédiments, dont des lignites, qui ont été exploités. Si la palynologie de ceux-ci est relativement bien connue, les données sur les mégarestes sont rares. La découverte d’un gisement du Pliocène supérieur (Reuvérien) particulièrement favorable permet d’apporter de nouveaux éléments, significatifs d’un point de vue paléoécologique et biogéographique. La flore, incluant des palmiers et des *Sciadopitys*, caractérise un « Sequoia-Moor », un type de forêt marécageuse qui n’avait jamais été mis en évidence en France conjointement par les micro- et les mégarestes. **Pour citer cet article :** M. Philippe et al., C. R. Palevol 1 (2002) 221–225. © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

paléobotanique / Tertiaire supérieur / *Sciadopitys* / France

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## Version abrégée

Relativement bien connu d’un point de vue palynologique [4, 10, 15, 16] le Tertiaire bressan, quoique lignitifère [3, 12, 14, 19], n’a jamais été étudié du point de vue des mégarestes végétaux, et seuls quelques « *Taxodiioxylon* » ont été signalés [14, 21, 23]. D’autres lignites néogènes franc-comtois ont fait l’objet d’études paléobotaniques et palynologiques conjointes [20], mais dans un contexte différent.

À la faveur des travaux de l’autoroute A 39, un niveau marno-sableux et ligniteux a été localisé à proximité de Colonne, Jura (Fig. 1). Il appartient probablement aux marnes de Commenailles, une formation d’âge Pliocène supérieur (Reuvérien, toit à environ  $2,4 \pm 0,2$  Ma [13, 19]). Les prélèvements ont été effectués à deux endroits où affleure ce niveau, l’échangeur de Bersaillin et l’aire de la « Jument-Verte », dans une couche argileuse riche en matière organique et pyrite microcristalline, pétrie de débris végétaux divers

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\*Correspondence and reprints.

E-mail address: philippe@cismsun.univ-lyon1.fr (M. Philippe).

(écorces, axes ligneux, bois, débris foliaires, feutrages racinaires) parautochtones, certains métriques. Les bois montrent un début d'attaque fongique de type pourriture brune [25].

Les douze fragments ligneux étudiés ont tous la même anatomie, similaire à celle du *Sciadopitys* actuel [18], sauf un qui est rapporté à *Taxodioxylon* Hartig. Un fragment de folioles de palmier ainsi que quelques aiguilles pédicellées de Conifères, dépourvues de cuticules, ont été reconnus. Les spores sont abondantes (Tableau 1), avec une part importante d'Osmonde, notamment pour la « Jument-Verte ». Les pollens sont dominés par les Abiétacées (*Pinus*, *Picea*, *Abies*, *Cedrus*, *Cathaya* et *Tsuga*). Parmi les Angiospermes sont représentés, entre autres, *Alnus*, *Quercus*, les Ericacées et Palmiers, ainsi que des Graminées.

*Sciadopitys* n'a pas été trouvé, quoique son pollen soit facilement reconnaissable [24]. Cependant, ce pollen est toujours faiblement représenté [15] et les taphonomies du bois et du pollen sont différentes [7]. Aujourd'hui, *Sciadopitys* ne se rencontre plus qu'au Japon, en climat maritime tempéré humide sur sols sableux à limoneux [2, 9, 27], mais, au Tertiaire, il était répandu dans le Paléarctique [6, 8, 11].

Des études paléocéologiques en Allemagne [17, 22] ont démontré que *Sciadopitys* occupait des tourbières bombées couvertes d'un boisement clair à Cyprès chauve (*Taxodium*), Palmiers (*Arécacées*) et pins (*Pinus*), une formation habituellement dénommée « Sequoia-Moor » [17]. Quoique le pollen de *Sciadopitys* se rencontre isolément plus au sud, jusqu'en Italie [1, 5, 6], le « Sequoia-Moor » est mis en évidence pour la première fois en France, ce qui étend largement vers le sud-ouest la distribution connue de cette phytocénose si particulière.

Dans la mesure où les exigences pédologiques du *Sciadopitys* actuel sont différentes de celle du *Sciadopitys* du Tertiaire européen, on peut affirmer que ce genre a changé d'écologie, même s'il reste un indicateur de climat doux [26]. Quoique la présence de palmiers ne permette pas d'écarter la possibilité de gels occasionnels, le climat du Reuvérien, au moment de ce dépôt, était probablement plus maritime et un peu plus chaud qu'aujourd'hui. La présence d'éléments clairement allochtones, comme *Cedrus* et *Cathaya*, qui vivent sous des climats semblables, mais n'appartiennent pas du tout au même type de forêt, corroborent ces indications paléoclimatiques.

## 1. Introduction

On the western border of the Jura Mountains, the Bresse Basin was active during the Tertiary [12, 19]. The related sedimentary succession includes fluvial and lacustrine deposits. During the Late Tertiary, mainly coarse fluvial sediments were deposited. They are surmounted by finer-grained sands and marls that commonly include 'lignite' [3, 14, 19]. This term is confusing, however, being sometimes used for isolated woody axes and sometimes for organic-rich levels with diverse plant remains. Both types are encountered in the studied material. These lignitic beds of the Bresse were still exploited shortly after the Second World War. They were extensively studied from a palynological point of view [4, 10, 15, 16]. The plant macroremains are, however, poorly known, the only data reported being 'wood of the *Taxodioxylon* type' [14, 21, 23]. Another Neogene lignite from the same region Franche-Comté was studied from both palynological and palaeobotanical points of view [20], but the geological and palaeoecological setting was quite different.

New material was collected in 1999 and 2001 during the construction of the highway A 39, in road-cuttings that occurred near the town of Poligny (Fig. 1). This includes a matrix bearing woody axes, barks, isolated leaves and rootlets, and palynomorphs. The present results deal with both micro- and macroremains.

## 2. Geological setting, material, and methods

The material comes from the vicinity of Colonne (Jura department, eastern France). It was found in road-cuttings along an access road to the highway A 39, at Bersaillin (Fig. 1), and at a rest area named 'Aire de la Jument-Verte' (in reference to the famous novelist Marcel Aymé), 2 km northward. At both localities, grey sandy marls cropped out, which include organic beds and a few coarser levels with gravel. One of the organic beds is particularly obvious, circa 50 cm-thick, with numerous trunks and branches, some woody debris being metric in size. The matrix is dark-grey, with a high content of organic matter and microcrystalline pyrite. Detritic sand fraction is low. The depositional environment was an organic swamp with low alluvial input. Plant remains include palynomorphs, leaf compressions without cuticle preserved, bark fragments, woody axes and mat-forming rootlets. Although the deposit is probably not autochthonous, as no rooting systems were observed in the underlying marls, transport was probably short, because the plant debris are unsorted and unrolled, whereas the alluvial input is low.

The stratigraphic assignation of these marls is difficult, because the outcrop is restricted. As it overlays the 'Sables de Foulenay' [13], the level probably belongs to the 'Marnes de Commenailles', a lateral equivalent of the 'Marnes de Foulenay', according to C. Petit. The 'Marnes de Commenailles' are Upper Pliocene

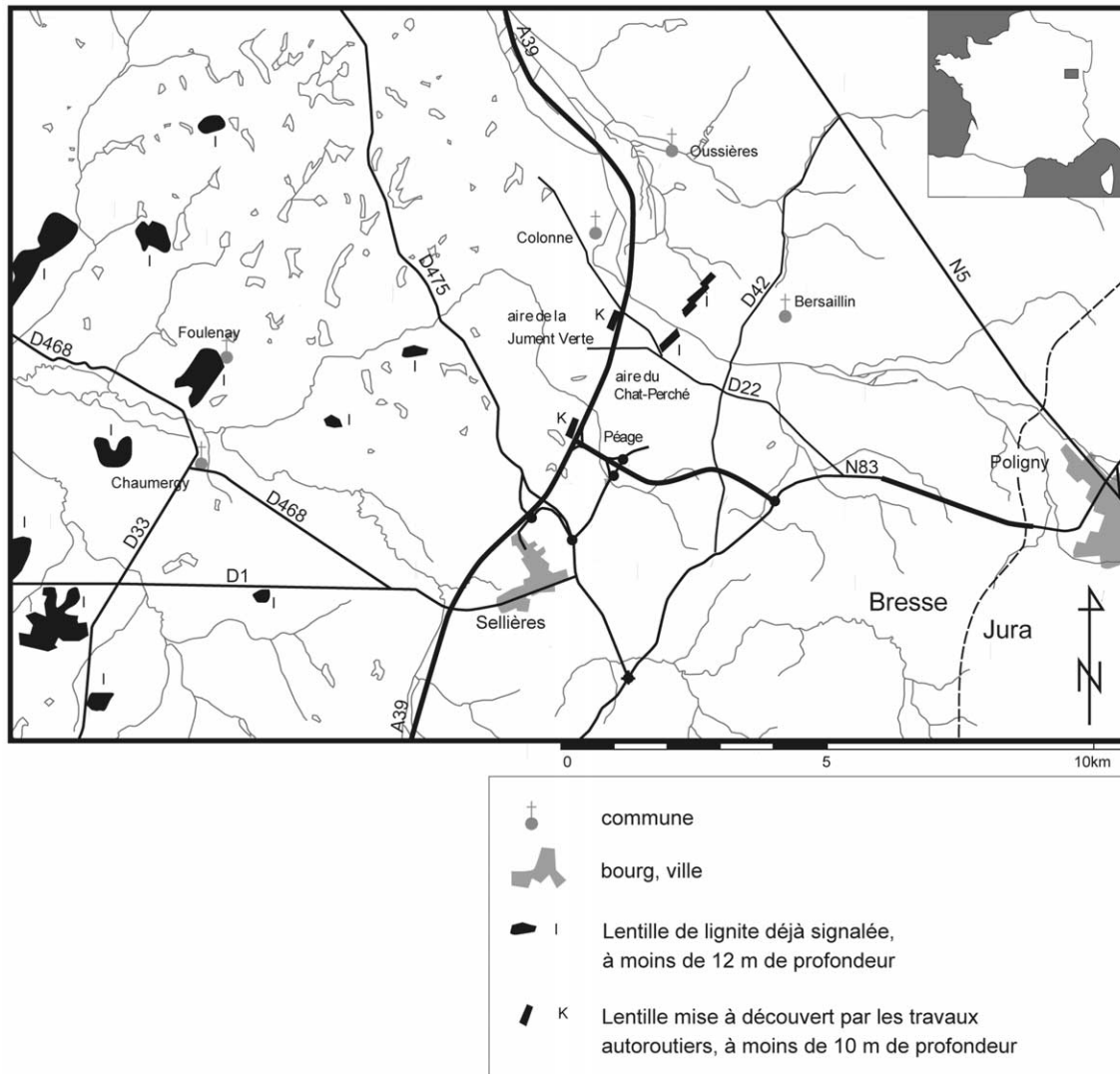


Fig. 1. Location of 'Péage de Bersaillin' and 'Aire de la Jument-Verte' along the highway A 39, Franche-Comté, northeastern France.

Fig. 1. Situation des localités, péage de Bersaillin et aire de la Jument-Verte, le long de l'A 39, Franche-Comté, Nord-Est de la France.

(Reuverian, top at ca  $2.4 \pm 0.2$  Ma) in age [19]. This is consistent with our palynological data from the level studied (see below).

Twelve samples of wood were studied. They all originate from axes exceeding 10 cm in diameter. One of them was taken from a trunk 35 cm in diameter. After 12 h in water, samples were boiled for 2 h, before being cut with a razor blade along the three xylological plans. Palynological preparation was performed, following the usual method. A gentle application of  $H_2O_2$  on the matrix allowed for removing a few cuticle fragments. However, cuticle structures were almost impossible to observe due to the presence of a dark content that Schulze reagent (nitric acid plus potassium chlorate) was unsuitable to clear. This precluded from studying cuticle structure.

### 3. Results

#### 3.1. Fossil woods

Almost all the samples have the same structure. It is a homoxylous wood, with narrow but clearly marked growth rings. In transversal view, the tracheid section is inconstant. Rays are mainly uniseriate, less than 2% being biseriate on one or two levels at most. Rays are numerous, narrow, and their height is rather low (ca 7.5 cells). The radial pitting of the tracheids is abietinean, uniseriate, rarely (less than 4%) biseriate and, then, with opposite pairs. Pits are rather large, covering the whole tracheid radial wall. Cross-fields have only one pore, rarely two. This pore is a large podocarpoid to taxodioid oculipore, occupying the whole field, in the early wood, whereas a single cupressoid oculipore is

observed in the late wood cross-fields. The ray-cell walls are smooth and unpitted, except for cross-fields. Axial parenchyma has not been observed. The wood underwent fungal attacks, displaying the pattern of an early stage of brown-rot wood decay [25]. This wood is clearly related to the extant genus *Sciadopitys* [18]. From a nomenclatural point of view, the morphogenus *Sciadopityoxylon* Schmalhausen cannot be used, as there are some uncertainties about its type specimen. Thus, this type from the Jurassic of Mangyschlack Peninsula (former USSR) may be related to *Xenoxylon* Gothan (pers. obs.). To stay out of this taxonomical/nomenclatural imbroglio, the wood studied herein is assigned to the morphogenus *Podocarpoxyylon* Gothan. A reliable specific name cannot be given without exhaustive reappraisal of the fossil wood complex of *Podocarpoxyylon/Taxodioxyylon* species, described up to now from the European Tertiary. The present data establish the first record of *Sciadopitys* type fossil wood in France. The fossil woods mentioned up to now from the Bressan Tertiary deposits all belonged to the type *Taxodioxyylon* Hartig [14, 21, 23, unpublished data].

The single specimen of fossil wood displaying a different anatomy belongs to this latter type, featuring common biseriate radial pitting and Sanio's rims, taxodioid oculipores, as well as axial parenchyma with smooth transverse walls.

### 3.2. Other plant macroremains

A fragment of a palm leaflet was recognised among the leaf remains. A few 'needles', resembling pedicellate conifer leaves, are also present. In some of them, the cuticles are preserved. However, any description or identification of these cuticles cannot be given herein because of methodological problems. Rootlets are outstandingly abundant all through the fossiliferous level, clearly indicating parautochtony.

### 3.3. Palynomorphs

The palynological results are given in Table 1. Spores are quite abundant, with a significant contribution of the hygrophytic and acidophilic taxon *Osmunda* (king-fern), especially in the 'Aire de la Jument-Verte'. At both sites, spores of *Sphagnum*, Anthocerotae and Polypodiaceae were also recognised. Pollen grains of *Sciadopitys* were absent, whereas the conifers as a whole were diversified. The Abietaceae are dominant and diverse (*Pinus*, *Picea*, *Abies*, *Cathaya*, *Cedrus*). Taxodiaceae, *Alnus*, Arecaceae (palm-trees) and Ericaceae (heathers) are present. The Poaceae (grasses) are poorly represented. The palynological spectrum clearly indicates that the level studied is older than the Pre-

Table 1. Percentages of the different palynomorph types encountered.

Tableau 1. Pourcentages des différents palynomorphes rencontrés.

	Bersaillin	Jument-Verte
Spores	33	23
of which <i>Osmunda</i>	1.5	13
Pollens	65	69
Abietaceae	56.5	61
of which <i>Pinus</i>	12	13
<i>Picea</i>	1	4.5
<i>Abies</i>	6.5	1
<i>Tsuga</i>	0	0.5
<i>Cathaya</i>	2.5	0
Taxodiaceae	0.5	1
Total Gymnosperms	57	62
Arecaceae	0	1
<i>Alnus</i>	1.5	4
Ericaceae	0	1
<i>Quercus</i>	0.5	0.5
Herbaceous Angiosperms	1	0.5
Total Angiosperms	8	7
Undetermined	2	8
Number counted	232	327

tiglian, which always displays significant amount of *Artemisia* and Poaceae in the Bresse area [16].

## 4. Discussion

In the Bresse region, the occurrence of both *Sciadopitys* and *Tsuga* pollen grains is frequent in the Pliocene. Such an association agrees with the age usually proposed for the « Marnes de Commenailles » [19]. Otherwise, the woods assert that *Sciadopitys* was well represented at this time-period. The palynological analysis, however, failed in recognising any *Sciadopitys*, although this pollen is typical [24]. Thus, the taphonomy of wood and pollen is very different [7]. Moreover, the fact that *Sciadopitys* pollens are usually in low percentages in palynological spectra of the Neogene of Bresse [4, 10, 15] may be a result of entomophily and of the related low pollen production.

The single extant species of the genus *Sciadopitys*, *S. verticillata*, is an endemic of Southern Japanese mountain areas. It grows within old-growth forest with *Chamaecyparis obtusa*, although rather heliophilous, on drained sandy or loamy soils (ph = 3.7 to 6.0), and under temperate maritime climate with high rainfall and moisture [2, 9, 27]. In the Tertiary, *Sciadopitys* is, however, represented all over the Palaeartic [6], and mainly by its pollen grains. Such a type of wood was found, for example, from the Pannonian of Hungary [8] and the Oligo-Miocene of Düren in Germany [11].

Outstanding palaeoecological studies were performed in Westfalia and central Europe [17, 22], which indicate

that *Sciadopitys* trees grew in the ‘Sequoia-Moor’. This raised bog swamp-forest was encountered around lakes, slightly over the water-table level. The forest was mainly composed of palm-trees (Arecaceae), true pines (*Pinus*), bald cypress (*Taxodium*) and umbrella-pine (*Sciadopitys*). Our results assert that a forest very similar to the German model occurred in northeastern France during the Pliocene. It is the first time that such a palaeoenvironment is demonstrated for France, with clear evidence of parautochtony from both micro- and macroremains. The occurrence of king-fern, heather and alder agrees with the inference of an acidic and hydromorphic soil. From a biogeographical point of view, although *Sciadopitys* is already known as pollen grains farther south up to Italy [1, 5, 6], our data extend significantly southwesternward the distribution of Pliocene *Sciadopitys* swamp-forest.

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