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Verdeña (Spain): Life and death of a Carboniferous forest community

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Abstract

The remains of a forest of 305 million years ago allow reconstructing its history of colonisation of a coastal sand bar and its destruction by marine flooding due to faulting in a high destructive deltaic setting. Sigillarian trees snapped off just above the rooting bases, whereas woody trees (cordaitaleans?) were uprooted by the unidirectional current, which oriented the fallen logs. This record puts a new perspective on reconstructions of Carboniferous forest mires. ***To cite this article: R.H. Wagner, J.B. Diez, C. R. Palevol 6 (2007).***

Résumé

Verdeña (Espagne) : vie et mort d'un peuplement forestier du Carbonifère. Les restes fossiles d'une forêt ayant existé il y a 305 millions d'années permettent de reconstituer l'histoire de son implantation sur une barre sableuse côtière et de sa destruction par une inondation marine liée à la destruction tectonique d'un système deltaïque. Les sigillaires arborescentes ont été tronquées juste au ras de leur système racinaire, alors que les arbres ligneux (*Cordaites* ?) ont été déracinés par un courant marin unidirectionnel, dans le sens duquel ils se sont alignés après leur chute. Ces nouvelles données autorisent un nouveau point de vue sur les interprétations des tourbières forestières du Carbonifère. ***Pour citer cet article : R.H. Wagner, J.B. Diez, C. R. Palevol 6 (2007).***

Keywords: Carboniferous; Cantabrian; Stratigraphy; Palaeoecology; Taphonomy; Flora; *Sigillaria*; *Cordaites*

Mots clés : Carbonifère ; Cantabrien ; Stratigraphie ; Paléoécologie ; Taphonomie ; Flore ; *Sigillaria* ; *Cordaites*

1. Carboniferous forests: historical

Coal seams in the Carboniferous of Europe and North America are normally found associated with fossil plant remains. Although some coals are simply enrichments in vegetable matter in lake deposits with both inorganic and organic matter, a substantial proportion of coal seams show underlying rootlet beds. These are commonly filled with appendices of *Stigmaria* and other kinds of lycopsid rooting structures. Overlying the coals it is not uncommon to find stands of standing trees, most often lycopsids although stands of *Calamites* also occur.

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There is a substantial amount of literature dealing with standing trees in Carboniferous deposits, and also with the rooting structures of the different kinds of plant involved. One of the first authors to deal comprehensively with these structures was Grand'Eury [4]. This mining engineer was a keen observer and his observations set out in elegant French are still worth reading, well over a century later. Grand'Eury ([5], p.48), working mainly on Stephanian deposits of the Massif Central, in south-central France, wrote that "*les écorces de Lepidodendron, de Sigillaria, de Calamites et de Calamodendron, simples et régulièrement aplaties, produisent une houille admirablement stratifiée que lamellent aussi bien les Aulacopteris que les feuilles des Cordaïtes*". This acknowledged that coals were layered sediments with flattened remains of the organic constituents of shallow lakes and mires. Grand'Eury [5] stated that all coals were entirely of vegetable origin, and sediments of a similar kind to the associated shales. Since then, a wider variety of origins is admitted, although the basic tenets are unchanged.

Grand'Eury [5] made first hand observations of the rooting structures in strata underlying coal seams. In these rootlet beds he distinguished *Stigmaria*, *Stigmariopsis* and *Cordaites* roots. *Stigmaria* was shown as laterally extensive, with a characteristic pattern of rootlet scars (stigmarian appendices), whilst *Stigmariopsis* was depicted as more deeply rooted (i.e. not quite as shallow as *Stigmaria*), and *Cordaites* with roots at a steeper angle ([5], plate 1, fig. 8). Although the picture illustrating these three types of rooting structures is labelled "*Partie inférieure de la couche de la Grille*", near Roche-la-Molière, it would seem that this is a composite picture. Grand'Eury [5] also illustrated the rooting structures of *Calamites*, also underlying a coal seam, and standing trees attributed to *Psaronius* (tree fern) in sandstone (op. cit., plates 2 and 3). Standing *Calamites* trees were illustrated from fine-grained sandstone overlying a coal. Similar observations abound in the literature, with special emphasis on the different position in sedimentary sequences.

Although Grand'Eury highlighted the various trees with their rather substantial rooting structures, one is also aware of rootlet beds consisting of fern rootlets of a much finer texture. These are increasingly common in Permian strata.

The different elements of Carboniferous forest mires have often been depicted in reconstructions. A compendium of reconstructions was published by Jongmans [10] as a special chapter in the book *Hout in alle tijden* (*Wood throughout time*). This provides a number of interesting pictures, which are often more imaginative than the observational drawings made by Grand'Eury. Worthy of note is a drawing by Unger (in [10] Afb. 1.62) who depicted a Carboniferous forest destroyed by catastrophic flooding. Although usually regarded as a curiosity, the catastrophic destruction of a forest may have been a more common event than is normally acknowledged. Another picture, reproduced by Jongmans, is a diorama from the Geology Museum of the Geological Survey in London. This shows a lycopsid tree with characteristic four cornered *Stigmaria* partially uprooted and broken in half. The inspiration for such a picture is a woody tree, which is the wrong example. Lycopsid trees, possessing little wood, and a large cortical area, can be shown to have decayed rapidly, with tissue collapse and flattening, if preserved in a horizontal position. Lycopsid periderm also provides a leathery surround to hollow trees, and splintering is out of the question. The extensive stigmarian rooting system would remain firmly anchored to the ground or be washed out entirely after separation from the stem. Lycopsid trees were unlikely to topple with the rooting structure attached. In published reconstructions it is a common mistake to depict flat-lying lycopsid trees as cylindrical stems. In fact, these trees are always found in a flattened condition due to the cortical tissue collapsing after rapid decay.

Most of the interest has been centred upon standing forests, that is, upright tree trunks in river overbank deposits, sheet flood sandstones, volcanic ash bands, etc. Less commonly, the reconstruction of Carboniferous forests is based on impressions, the reason being that plant impressions usually relate to drifted, remains with assemblages ranging from allochthonous to parautochthonous and, only very occasionally, autochthonous. With regard to

Fig. 1. Composite showing steeply dipping sandstone (rootlet bed) in abandoned opencast site (**A** above), and, in the middle (**C**), a detail with large first generation stigmarian rooting bases (a), as well as smaller (second generation) rooting bases (b), and a fallen (snapped off) log of a (second generation) cannelate *Sigillaria* (c), as reconstructed alongside (**B**). Below, the imprint of an uprooted woody tree (**D**), and, alongside, the imprint of a second generation stigmarian rooting base (**E**).

Fig. 1. Planche montrant un front de grès escarpé dans une carrière à ciel ouvert abandonnée (**A** en haut) et au milieu (**C**), un détail de l'installation de la première génération des grands systèmes racinaires de type *Stigmaria* (a), ainsi que de plus petits (deuxième génération) (b) et un tronc couché (deuxième génération) d'une sigillaire cannelée (c), telle que reconstituée en (**B**). En bas, empreinte d'un tronc ligneux déraciné (**D**), le long de laquelle on observe l'empreinte d'un système racinaire de lycopside de deuxième génération (**E**).