# Plants and their interactions with microorganisms in early terrestrial environments


## C. Strullu-Derrien



*La colonisation du milieu terrestre par les plantes, il y a environ 460 millions d'années, représente un événement capital dans l'histoire de la Terre. Les premières plantes terrestres ont joué un rôle majeur dans l'écologie des premiers écosystèmes terrestres, qui étaient déjà diversifiés. Des champignons et autres microorganismes de mode de vie fongique, étaient associés aux plantes dans différents types d'interactions (parasitique, symbiotique, saprophytique). Les macro-restes de plantes apparaissent dans le registre fossile au Silurien mais deviennent plus abondants au Dévonien. Le Dévonien inférieur est une période clé pour l'étude de l'évolution des plantes et de la mise en place de leurs différents constituants. C'est également le cas pour l'étude des champignons et autres microorganismes. Des fossiles plus récents (Trias supérieur) apportent des informations sur la diversification des écosystèmes. Mes recherches portent sur la structure « bois » et sur les microorganismes exceptionnellement préservés associés aux plantes.*


**1 : Plant arthropod interactions in a Triassic permineralized peat from Hopen, Svalbard Archipelago (Arctic)**

Siliceous permineralized peat from Hopen Island, Svalbard Archipelago, shows a dense mass of roots preserving fine anatomical details of various stages of primary and secondary vascular tissue development. The presence of moderately defined rings with few latewood cells in the secondary xylem attests to growth in a seasonal environment. The observed anatomy of the wood favors bennettitalean affinities for the roots.

**Fig. 1.** *Benettitalean roots.*
***Fig. 1**. Racines de Benettitale.*

Evidence of a rich fauna of detritivores inhabiting the peat profile is represented in the form of extensive damage to cortical tissues of dead roots and abundant coprolites preserved both within chambers excavated in the plant tissues and in the peat matrix.

**2 : Hydraulics properties of the earliest wood (Armorican Massif) calculated from measurements taken from PPC-SRµCT images**

Understanding the early evolution of wood requires a detailed documentation of early fossil materials. We recently discovered the « *plant from Châteaupanne* », the oldest woody plant, based on ca 407 million year old fossils from the Armorican Massif, western France. The axes of the plant were permineralized in pyrite. We used propagation phase contrast X-ray synchrotron microtomography (PPC-SRµCT) to create detailed submicron scale three-dimensional images that

enabled virtual dissection of the wood and characterization of its properties.
Hydraulic and biomechanical properties were calculated from measurements derived from the PPC-SRµCT images.
The specific hydraulic conductivity $K_s$ was calculated as 17.4 kg $m^{-1}$ $s^{-1}$ $MPa^{-1}$, and the mean cell thickness-to-span ratio $(t/b)^2$ was 0,0372. Results show that the wood was suited to high conductive performance with low mechanical resistance to hydraulic tension. We argue that axis rigidity in the earliest woody plants initially evolved through the development of low-density porous woods.

**Fig. 2.** Prediction of lumens conductance based on a transverse section of part of xylem of the plant from Châteaupanne extracted from the PPC-SRµCT volume
***Fig. 2.*** *Evaluation de la conduction à partir d'une image en section transversale du xylème de la plante de Châteaupanne extraite du volume PPC-SRµCT*

**3 : Confocal laser scanning microscopy and light microscopy for the study of microorganisms (Rhynie and Windyfield cherts, Scotland)**
Confocal laser scanning microscopy (CLSM) was developed for use in biology to image in three dimensions the structural components of tissues and cells. The method has not yet been widely employed in Palaeobotany, but it has many potential applications, especially in the imaging of petrified materials.
We used a Nikon A1-Si laser-scanning confocal microscope with 4 different laser lines and equiped with Nikon NIS-Elements software. The information we obtained was used to create detailed three-dimensional reconstructions of Lower Devonian microorganisms (e.g. algae, oomycetes, fungi). Results enabled us to clarify the affinities of the microorganisms and to interpret their paleoenvironment.

**Fig. 3.** Rhynie chert bloc showing longitudinal sections of Rhynia gwynne-vaughanii axes.
***Fig. 3.*** *Bloc de chert de Rhynie montrant des axes de Rhynia gwynne-vaughanii en section longitudinale.*

## Collborations

Paul Kenrick, Natural History Museum London; Jean-Philippe Rioult, Université de Caen ; Marc Philippe, Université de Lyon; Steve McLoughlin, Natural History Museum Stockholm; Eric Badel, INRA et Université Clermont-Ferrand ; Hervé Cochard, INRA et Université Clermont-Ferrand ; Alain Le Hérissé, Université de Brest ; Nigel Trewin, Université d'Aberdeen

## Références associées

1. **Strullu-Derrien C.**, McLoughlin S., Philippe M., Mork A. and Strullu D.G. 2012. Arthropod interactions with bennettitalean roots in a Triassic permineralized peat from Hopen, Svalbard Archipelago (Arctic). Palaeogeog. Palaeoclim. Palaeoecol., 348-349, 45-58.
2. **Strullu-Derrien C.**, Kenrick P. 2013. Champignons et plantes: une union très ancienne. La Recherche, 481, 50-53.
3. **Strullu-Derrien C.**, Kenrick P., Badel E., Cochard H. and Tafforeau P. 2013. An overview of the hydraulic systems in early land plants. IAWA Journal, Special Issue, 34(4), 333-351 (invited paper).