



Supporting Online Material for

A Simple Type of Wood in Two Early Devonian Plants

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SOM Text

A vascular cambium evolved independently in several Devonian and Carboniferous plant lineages

Fossil evidence indicates that the vascular cambium has arisen multiple times and that the vascular cambia of different plant lineages differ in organization and function (6). Extinct arborescent lycophytes (Late Devonian to Permian), woody sphenophytes (Late Devonian to Mesozoic), and some fern precursors (Middle Devonian to Early Carboniferous cladoxylopsids and the Late Devonian *Rhacophyton*) possess a unifacial vascular cambium, generating only a limited amount of secondary xylem (1, 7). Lignophytes (progymnosperms and seed plants) exhibit a bifacial vascular cambium producing both secondary xylem and phloem (1, 7).

Sphenophyllum is considered as the only plant outside of the lignophyte lineage with a bifacial cambium (7, 8). In lignophytes, cambium initials frequently divide anticlinally, while they never do in *Sphenophyllum* (6).

About the correlation between small size and secondary growth in plants

Small size does not necessarily mean absence of secondary growth in plants: a wide range of extant herbaceous eudicots are able to produce a small amount of secondary tissues.

The largest Early Devonian plants belong to the genus *Pertica* Kasper and Andrews; their height reached 1 to 2 m. Their anatomy is unknown. Radial rows of tracheids have been described for the smaller *Psilophyton* Dawson (9, 10), but they were interpreted as representing aligned primary xylem. As judged from the published illustrations (9, 10) and our own preparations, they differ from our specimens in lacking the single-walled spaces.

About the localities

Locality 1 is an outcrop in the Châteaupanne quarry (Montjean-sur-Loire, Armorican Massif, France) in the Chalonnes Formation; it has been assigned a late Pragian/earliest Emsian age (11). Locality 2 is an outcrop in the Campbellton Formation, northern New Brunswick (Canada); it has been assigned a late Emsian age (12) on the basis of the spore assemblage indicating the upper part of the “*annulatus-sextantii*” spore zone.

The palynological assemblage observed in the sediments containing the fossil plants at Châteaupanne has been studied. Samples have been prepared using standard

palynological techniques. The palynofacies is dominated by brown to black phytodebris such as cuticles and tracheids. The palynological assemblage is strongly dominated by trilete spores. Rare biostratigraphically insignificant acritarchs are present. Both are usually badly preserved, brown to dark brown in colour and often strongly fragmented. The spore assemblage is mainly composed of *Ambitisporites avitus*, *Amicosporites jonkeri* (Riegel), probable specimens of *Apiculiretusispora brandtii*, *A. plicata* (Allen), *Archaeozonotriletes chulus*, *Dibolisporites wetteldorfensis*, *Emphanisporites multicostatus* and *E. rotatus*. The assemblage is similar to those collected earlier from the same quarry (11), in layers stratigraphically above and below the sample studied here. The age of the fossiliferous samples may be deduced from the following observations.

(i) The first appearance datum (FAD) of most biostratigraphically significant spores is Early Devonian, with the possible exception of *E. multicostatus* whose FAD is Late Silurian. The FAD of *A. plicata* is Lochkovian, and the FAD of *A. brandtii* is either latest Pragian or earliest Emsian (13). *A. brandtii* and *A. plicata* are morphologically almost similar and often difficult to distinguish. They most probably belong to a single morphon (14). The exine of the youngest end member of the morphon, *A. brandtii*, is clearly composed of two layers: the younger the specimens are, the more distinct the layers are. We do not see the two layers in the specimens from Châteaupanne, which probably means that they are old representatives of the morphon.

(ii) The diameter size of most spores of the assemblage is small, approximately 25-40 µm. This suggests a Lochkovian to Pragian maximum age (15, 16).

(iii) The FAD of *D. wetteldorfensis* is early Pragian in age, W Interval Zone (15). Specimens are 25-35 µm in diameter; they are the smallest and the most abundant spores of the assemblage. Observations on Belgian and German assemblages (15, 17) have shown that *D. wetteldorfensis* of similar size first appear in the lowest part of the Opplé Biozone PoW [early Pragian to early Emsian in age (15)]. The size of the *D. wetteldorfensis* specimens becomes larger in younger sediments. The same observation holds for the other samples of the same area (11).

In the absence of characteristic Emsian species, according to the above-mentioned observations, and according to data on samples collected below and above the fossiliferous plant layers (11), a late Pragian age is the most likely for the assemblage, even though an earliest Emsian age cannot be excluded.

About the affinities of the plants

Details of anatomy are consistent with a basal euphyllophyte affinity for the Châteaupanne and the New Brunswick plants. Both plants are close to the genus *Psilophyton*. Their metaxylem is comprised of P-type tracheids (18) with scalariform bordered pits. Tracheids in transverse section are polygonal (5-8 sides). The transverse

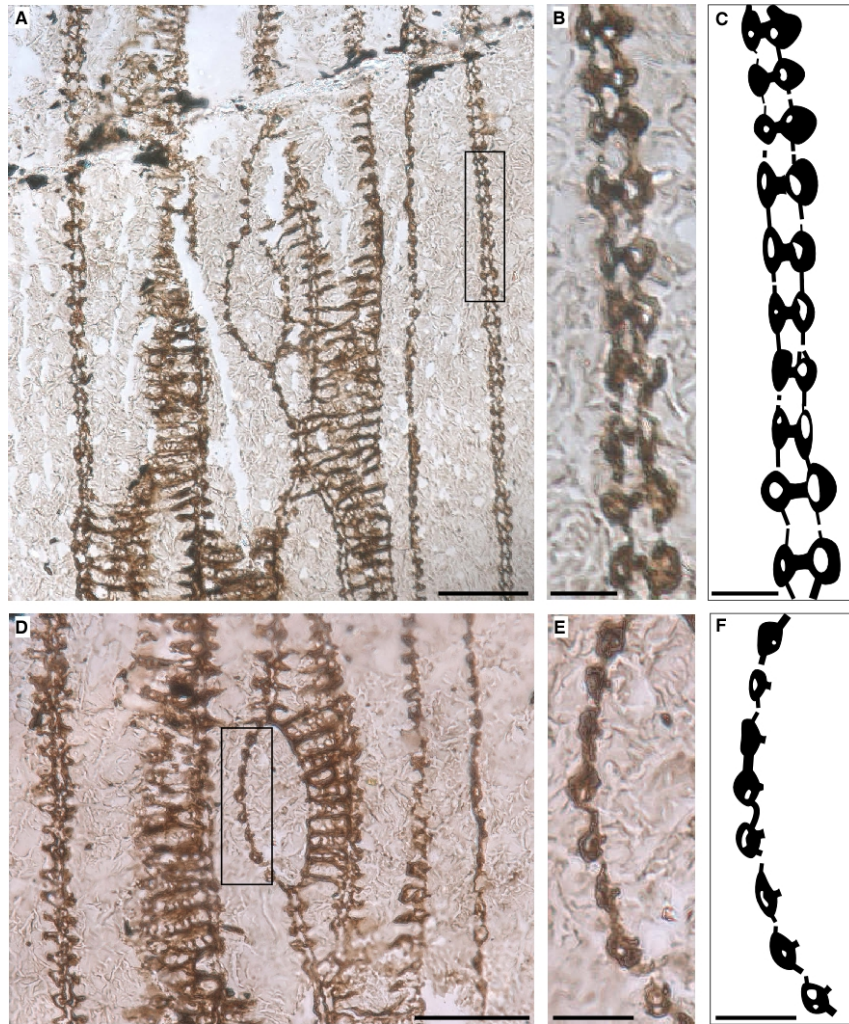
sections of the plant from France show a massive circular xylem strand with a rounded to elongate centrarch protoxylem area (fig. S1).

Fig. S1.



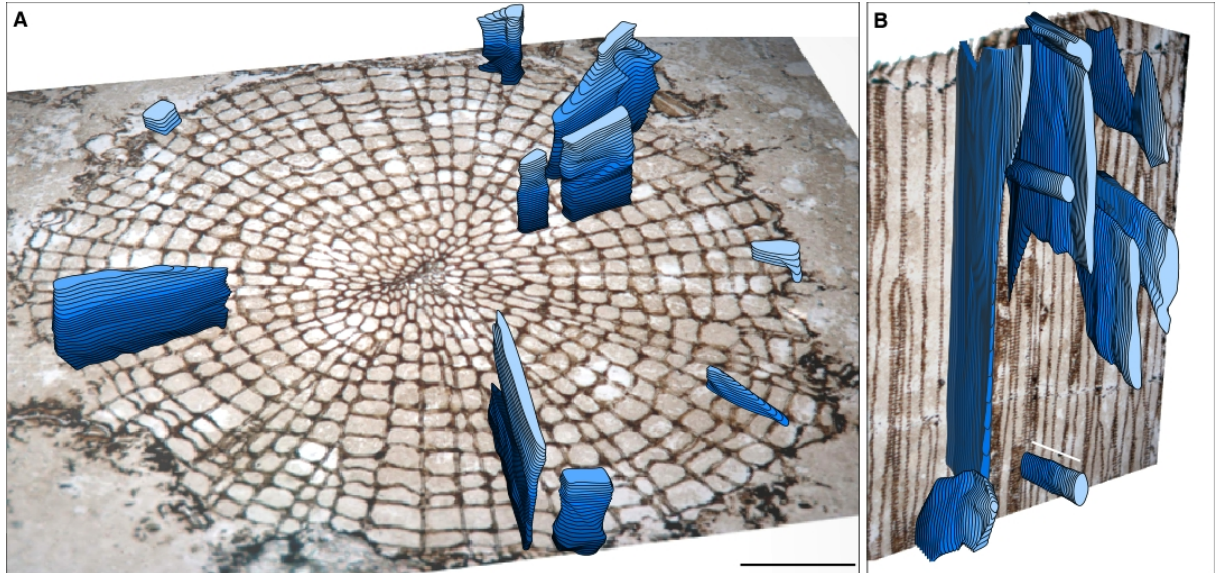
Transverse section of an axis showing a circular xylem strand with a rounded centrarch protoxylem area, and considerable secondary xylem. White arrows indicate doubling of xylem cell rows; grey arrows indicate possible intrusive growth. Scale bar, 100 μm . CP9-1-2-B2.

Fig. S2.



Comparison of a tracheid/tracheid double wall (A-C) with a tracheid/ray single wall (D-F). Scale bar for A and D, 50 µm; scale bar for B-C and E-F, 10 µm. CP16-1-CL.

Fig. S3.



Semi-schematic reconstructions of the spatial distribution of the rays. (A) Transverse section; distribution reconstructed on the basis of 21 peels. Scale bar, 200 μm . CP9-1-2-B. (B) Tangential section; distribution reconstructed on the basis of 10 peels. Scale bar, 100 μm . CP16-1-CL.

References

1. M. J. Donoghue, Key innovations, convergence, and success: Macroevolutionary lessons from plant phylogeny. *Paleobiology* **31**, 77 (2005). [doi:10.1666/0094-8373\(2005\)031\[0077:KICASM\]2.0.CO;2](https://doi.org/10.1666/0094-8373(2005)031[0077:KICASM]2.0.CO;2)
2. J. M. Dannenhoffer, P. M. Bonamo, The wood of *Rellimia* from the Middle Devonian of New York. *Int. J. Plant Sci.* **164**, 429 (2003). [doi:10.1086/374198](https://doi.org/10.1086/374198)
3. M. W. Bannan, Origin and cellular character of xylem rays in gymnosperms. *Bot. Gaz.* **96**, 260 (1934). [doi:10.1086/334470](https://doi.org/10.1086/334470)
4. N. P. Rowe, T. Speck, in *The Evolution of Plant Physiology*, I. Poole, A. R. Hemsley, Eds. (Elsevier Academic Press, Kew, UK, 2003), pp. 297–325.
5. R. A. Berner, Z. Kothavala, GEOCARB III: A revised model of atmospheric CO_2 over Phanerozoic time. *Am. J. Sci.* **301**, 182 (2001). [doi:10.2475/ajs.301.2.182](https://doi.org/10.2475/ajs.301.2.182)
6. M. A. Cichan, T. N. Taylor, in *The Vascular Cambium*, M. Iqbal, Ed. (Wiley, Somerset, UK, 1990), pp. 213–226.
7. R. Spicer, A. Groover, Evolution of development of vascular cambia and secondary growth. *New Phytol.* **186**, 577 (2010). [doi:10.1111/j.1469-8137.2010.03236.x](https://doi.org/10.1111/j.1469-8137.2010.03236.x)
[Medline](#)

8. D. A. Eggert, D. D. Gaunt, Phloem of *Sphenophyllum*. *Am. J. Bot.* **60**, 755 (1973).
[doi:10.2307/2441169](https://doi.org/10.2307/2441169)
9. H. P. Banks, S. Leclercq, F. M. Hueber, Anatomy and morphology of *Psilophyton dawsonii*, sp. nov. from the late Lower Devonian of Quebec (Gaspé), and Ontario, Canada. *Paleontogr. Am.* **8**, 77 (1975).
10. J. B. Doran, A new species of *Psilophyton* from the Lower Devonian of northern New Brunswick, Canada. *Can. J. Bot.* **58**, 2241 (1980). [doi:10.1139/b80-259](https://doi.org/10.1139/b80-259)
11. C. Strullu-Derrien *et al.*, The early land plants from the Armorican Massif: Sedimentological and palynological considerations on age and environment. *Geol. Mag.* **147**, 830 (2010). [doi:10.1017/S001675681000004X](https://doi.org/10.1017/S001675681000004X)
12. J. B. Richardson, D. C. McGregor, Silurian and Devonian spore zones of the Old Red Sandstone Continent and adjacent regions. *Geol. Surv. Can. Bull.* **374**, 1 (1986).
13. D. C. McGregor, Lower and Middle Devonian spores of Eastern Gaspé, Canada. *Palaeontogr. Abt B* **142**, 1 (1973).
14. J. B. Richardson, T. R. Lister, Upper Silurian and Lower Devonian spore assemblages from the Welsh Borderland and South Wales. *Palaeontology* **12**, 201 (1969).
15. P. Steemans, *Palynostratigraphie de l'Eodévonien dans l'ouest de l'Europe* (Service Géologique de Belgique, Bruxelles, Belgique, 1989).
16. A. Traverse, *Paleopalynology* (Springer, Dordrecht, Netherlands, 2007).
17. E. P. Lanninger, Sporen-Gesellschaften aus dem Ems der SW-Eifel (Rheinisches Schiefergebirge). *Palaeontogr. Abt. B* **122**, 95 (1968).
18. P. Kenrick, P. R. Crane, *The Origin and Early Diversification of Land Plants: A Cladistic Study* (Smithsonian Institution Press, Washington, DC, 1997).