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## Vegetation dynamics in the Early–Middle Pennsylvanian coal swamps of the Nord-Pas-de-Calais Coalfield, France

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### Abstract

During recent years, different studies have focused on characterizing plant diversities in the Carboniferous environments of the Variscan Foreland. One of these areas, the Nord-Pas-de-Calais Coalfield, has a Namurian–Westphalian sequence that has historically yielded abundant evidence of vegetation change, but to date, little attention has been paid to its macrofloral diversity dynamics. Here we show, for the first time, a comprehensive characterisation of the diversity changes and macroevolutionary patterns from this coalfield. The results show evidence of low levels of species richness during the Namurian, followed by an exponential diversification at the base of Westphalian. Duckmantian–Bolsovian species diversity continues to progressively increase, suggesting relatively stable conditions at that time. Maximum species richness is observed at the mid-Bolsovian followed by a major depletion during the Asturian. Overall, this pattern is quite similar to that seen in other parts of the Variscan Foreland. However, we see Nord-Pas-de-Calais vegetation diversified earlier than those in the British parts, probably because the dynamics of marine incursions and lacustrine conditions delayed its development in the latter areas. Furthermore, we also see the Asturian decline of the Nord-Pas-de-

Calais coal swamp occurred later than in other basins, such as in the Pennines, Ruhr and South Wales. This scenario suggests that the collapse of this biome was probably caused by increased sediment influx and reduced subsidence, resulting from the northwards migration of the Variscan Mountains. This further supports other studies in Europe advocating that climate change was at most only a subsidiary factor in the collapse of the Pennsylvanian coal swamp biomes.

**Keywords:** Namurian; Westphalian; biodiversity; palaeobotany; Variscan Foreland

## 1. Introduction

The foreland that developed north of the Variscide orogen in tropical Euramerica during the late Carboniferous (Opluštil and Cleal, 2007; Cleal, 2008a, 2008b; Opluštil et al., 2016; Knight et al., 2023; Opluštil and Schneider, 2023) was covered by about  $8 \times 10^5$  km<sup>2</sup> of wetlands, often referred to as coal swamps (Cleal and Thomas, 2005; Cleal, 2018). The result has been a belt of coal-bearing strata between the Canadian Maritimes and northern Turkey, containing a 10 Myr fossil record of this wetland biome (Cleal et al., 2009, fig. 1; Opluštil and Schneider, 2023). Numerous isochronous beds, notably eustatic marine bands (e.g., Bless et al., 1977) and volcanic ash beds (“tonsteins” – e.g., Bouroz, 1967), allow detailed correlations of the successions in and between the coalfields, making it possible to document the changes in the biotas across this substantial area. Evidence from modern-day vegetation has shown that species richness is a sensitive indicator of extrinsic environmental change (e.g., Magurran, 2013). The objective of this paper is to investigate whether there is a correlation between ecological factors and vegetation diversity during the Carboniferous period. Specifically, we aim to explore the impact of climatic cooling associated with the Late Palaeozoic Ice Age (e.g. Fielding et al., 2008 and Montañez and Poulsen, 2013) and landscape disturbance caused by the Variscan Orogeny on vegetation diversity. (e.g., Besly and Kelling, 1988).

The Nord-Pas-de-Calais Coalfield (Fig. 1) lies near the centre of the belt of Variscan Foreland coalfields (Cleal et al., 2009, 2011; Cleal and Cascales-Miñana, 2019, fig. 1). It has an almost complete succession through much of the Namurian and

Westphalian (Becq-Giraudon, 1983; Laveine, 1987; Guéguen et al., 2009; Fig. 2). These strata yield abundant adpression floras (macrofloras) that have been studied over the last century and a half (e.g., Brongniart, 1828; Boulay, 1876; Zeiller, 1888; Carpentier, 1913; Danzé-Corsin, 1953; Danzé, 1956; Buisine, 1961; Laveine, 1967, 1987; Laveine et al., 1978; Laveine and Goubet, 1995; Laveine and Belhis, 2007). In this paper, we collated the distribution of meaningful fossil-species through the Nord-Pas-de-Calais succession and then used this to estimate patterns of vegetation diversity in this part of the coal swamps. We then compared the results of similar studies undertaken in other Variscan coalfields (Cleal, 2005, 2007, 2008c; Cleal et al., 2007, 2009; Uhl and Cleal, 2010; Opluštil et al., 2017).

## 2. Geological background

Throughout this paper we used the West European Regional Chronostratigraphy as outlined by Wagner (1974, 2017) and Wagner and Winkler Prins (2016), as it expresses the stratigraphical relationships of these terrestrial, coal-bearing sequences better than the Global IUGS Chronostratigraphy (Cohen et al., 2013), which is based on marine sequences.

The Nord-Pas-de-Calais Coalfield has approximately 1150 km<sup>2</sup> of formerly mined concessions, over an area of about 105 km by 8 km (Fig. 1). The basin contains a paralic sequence (Bouroz, 1969) deposited in the rapidly subsiding foredeep near the Variscan Front (Laurent et al., 2021). The sequence is divided into five formations and twelve members (in French, termed *Assise* and *Faisceau*, respectively) ranging from the Arnsbergian (Namurian) to the lower Asturian (Westphalian) (Fig. 3). These lithostratigraphic units are delimited by coalfield-wide marine bands and tonsteins (Bouroz, 1960a, 1969; Becq-Giraudon, 1983). The Namurian deposits are predominantly marine shales, sandstones, and limestones, with generally low diversity, allochthonous macrofloras (Chalard, 1960; Fig. 4). However, continental influence increases from the upper St. Georges Member and Marie Member, with a declining number of marine bands and increasing macrofloras (Fig. 4). The Westphalian begins at the base of the Olympe Member of the Flines Formation (Fig. 5). This latter member is thin (15 to 90 m from west to east) and has numerous marine

bands but relatively few coals. The overlying Vicoigne Formation, whose base is marked by the *Laure* Marine Band, has major coals, up to 12 m thick, and has yielded abundant macrofloras that span much of the Langsettian Substage (Laveine, 1987). Two members (Chandeleure and Modeste) are recognised, separated at the Graziella Tonstein but there is no significant change in the macrofloras at this level (Fig. 5). The boundary with the overlying Anzin Formation is placed at the *Poissonnière* Marine Band, which is equivalent to the Amman Marine Band in the Westphalian stratotype in Britain (Owens et al., 1985) and defines the boundary between the Langsettian and Duckmantian Substages. The Anzin Formation continues to have thick coals and abundant macrofloras. It is divided into two members (Meunière and Pouilleuse) at the Wingles Marine Band (Bouroz, 1960b), with the lower member being characterised by numerous freshwater faunal horizons, and the upper member by having fewer freshwater horizons and thinner coals (Fig. 5).

The base of the overlying Bruay Formation is placed at the distinctive *Rimbert* Marine Band, whose thickness can exceed 30 m and is remarkably rich in fauna (Fig. 5). It correlates with the *Aegiranum* Marine Band in the Westphalian stratotype in Britain and marks the base of the Bolsovian Substage (Owens et al., 1985). Four members are recognised in the Bruay Formation. The Six-Sillons Member is very similar to the underlying Pouilleuse Member in terms of sedimentology, flora, and fluvial fauna, but has a greater number of tonsteins (Fig. 5). The overlying Ernestine is characterized by numerous, thick, extensively-exploited coal seams; also by a distinctive feldspar-rich arkosic sandstone called the Sainte-Croix sandstone (Dollé, 1958). The Dusouich Member also contains numerous, economically-important coals, but is distinguished from the Ernestine Member by the presence of abundant *Neuropteris ovata* Hoffmann, regarded as an important index for the Asturian Substage (Laveine, 1977); the base of the Dusouich Member is placed at the Talence Tonstein (Fig. 5). The fourth and highest member (Edouard) is distinguished by a distinctive conglomerate at its base (the so-called *poudingue d'Edouard*), probably the result of uplift of the Variscan Orogen to the south; immediately overlying this conglomerate is Tonstein Valence (Fig. 5), which has been correlated with the lower Asturian Tonstein 1 of the Saar-Lorraine basin (Bouroz, 1967). The upper limit of the

Edouard Member is marked by the overburden of Late Cretaceous age, separated by a major erosional discordance (Becq-Giraudon, 1983).

### 3. Methods

Late Carboniferous coal swamp vegetation can be divided into eight broad, partly informal plant groups: (1) lycopsids, (2) calamite sphenopsids, (3) sphenophyll sphenopsids, (4) non-marattialean ferns, (5) marattialean ferns, (6) lyginopteridaleans, (7) medullosaleans, and (8) cordaitales (e.g., Cleal, 2018). Since there was a strong ecological segregation of these plant groups between habitats within the coal swamps (e.g., DiMichele et al., 2001; DiMichele, 2014), it makes sense to look separately at the diversity dynamics of each of these plant groups.

Two approaches were used with the aim of determining the pattern of changing vegetation diversity from the macrofloral record. First, we looked at the changing species-richness for the selected plant parts for each of the major plant groups (as discussed in Section 4) through the stratigraphical succession. We used the range-through method, where a species is counted as being present at a stratigraphical level if it has been documented both above and below that level (Boltovskoy, 1988). This approach avoids the problems of uneven sampling through the succession and, although it can obscure fine-scale variations in species diversity, it still allows the broad vegetation trends to be recorded. Separate diversity curves were plotted for the eight major plant groups and then plotted as stacked charts to reveal the pattern of total species richness. Importantly, this facilitates comparisons with previous studies on Variscan coalfield macrofloras (Central and South Pennines, South Wales and Ruhr basins), which used the same approach (Cleal, 2005, 2007, 2008c; Uhl and Cleal, 2010).

Second, a set of evolutionary metrics were evaluated. We used the boundary-crosser method to calculate per-capita origination and extinction rates (e.g., Warnock et al., 2020; Capel et al., 2022). Per-capita rates are singleton-free metrics based on the proportions of range-through and boundary-crossing taxa observed in a given interval (see Foote, 2000, table 1, for implementation). These rates (1) summarize the changing pattern underlying the diversity distribution, (2) derive directly from

branching theory instead of a normalization of the number of taxa per interval, and (3) assume that the number of lineages depends only on the observed taxonomic rates (Foote, 2000). It provides a rate regardless of the origination-extinction magnitude frequently used as a descriptor of diversity changes. Other metrics, such as Sepkoski or Van Valen rates (Cascales-Miñana et al., 2013, table 1) were also considered. However, since the proportion of single-appearance data is almost negligible, no significant differences were observed.

#### 4. Macrofloral data

Primary data were extracted from the classic monographs on the Nord-Pas-de-Calais medullosaleans, lyginopteridaleans and ferns (Danzé-Corsin, 1953; Danzé, 1956; Dalinval, 1960; Buisine, 1961; Laveine, 1967). These were supplemented by taxonomic lists that have given data for the lycopsids, sphenopsids, and cordaites (Zeiller, 1888; Carpentier, 1913; Bertrand, 1914, 1919; Corsin and Corsin, 1970, 1971; Laveine, 1977, 1987). Together, these sources provide a full overview of the species dynamics of the Nord-Pas-de-Calais Coalfield macrofloras (Fig. 6).

Since this analysis is aimed to determine underlying patterns of vegetation taxonomic diversity, not all fossil-taxa were collated. Following the approach summarised by Cleal et al. (2012), the fossil-species of just one plant part per plant group were collated: for lycopsids, the bark/periderm species; for the cordaitales, the seed and pre-pollen cone species, and for the other groups, the foliage species. Although this may not be a perfect solution to the problem of fragmentation of the plant remains during preservation and the modular evolution where different plant parts have changed at different rates, Cleal et al. (2012) argued that it is the most robust way of determining the broad pattern of vegetation diversity dynamics from the upper Carboniferous macrofloral record.

The fossil-species were collated against the formations and members in the currently-used lithostratigraphical classification for Nord-Pas-de-Calais (e.g., Bouroz, 1969; Becq-Giraudon, 1983; Figs. 4, 5). Following the approach used in the aforementioned palaeobotanical monographs, each member has been divided into three informal subunits (lower, middle, upper). In total, we traced the stratigraphical

distribution of 255 plant macrofossil species. The resulting dataset is available from supplementary files (Table S1).

## 5. Results

The changing pattern in species richness is shown in Fig. 6. The Namurian represents a generally low diversity interval (0–20 species), with approximately even representation of lycopsids, sphenopsids, lyginopteridaleans and medullosaleans. However, there are small diversity pulses at the top of the Stérile Member and the base of the Marie Member, driven by medullosalean and lyginopteridalean pteridosperms, respectively. Also notable is a significant increase in lycopsid diversity towards the top-Namurian.

Species richness increases exponentially through the Olympe Member (lowermost Westphalian) to reach ca. 60 species by the base of the Vicoigne Formation, mainly driven by increases among non-marattialean ferns and pteridosperms (Fig. 6). Species diversity then continues to grow more gradually through the Vicoigne and Anzin formations (Langsettian–Duckmantian) eventually reaching about 100 species by the upper Duckmantian Pouilleuse Member. A further increase is then recorded through the lower Bruay Formation (Bolsovian), reaching a peak in the upper Six-Sillons Member of > 110 species, which includes a notably high diversity of non-marattialean ferns and medullosalean pteridosperms (Fig. 6).

A significant reduction in diversity then occurs through the two upper (Asturian) members of the Bruay Formation (Asturian) declining to ca. 40 species at the top of the succession. This depletion of species sees more than a half of the Bolsovian flora disappearing, affecting all groups of ferns and pteridosperms, resulting in a more lycopsid-dominated flora.

The per-capita origination-extinction rate values of overall plant diversity are plotted in Fig. 7A. As is to be expected, there are high origination values in the lower part of the succession (Namurian–lowermost Langsettian) and high extinction (extirpation) values in the upper (Asturian) part of the succession. In the rest of the succession, total origination levels tend to be higher than extinction, explaining the overall increase in diversity.



However, some differences are observed between plant groups. For instance, the highest origination levels for lycopsids are observed in the lowermost and uppermost Langsettian (Fig. 7B), while the most significant sphenopsid expansions are observed in the uppermost part of Namurian and the Duckmantian (Fig. 7C). Results further show high origination levels in the upper Namurian, lowermost Duckmantian and Bolsovian among ferns (Fig. 7D), while lyginopteridalean and medullosalean pteridosperms mainly diversify during the lower Westphalian. Moreover, the main lycopsid and sphenopsid disappearances occur at the top Duckmantian and lower Bolsovian, respectively (Fig. 7B, C). The main fern and pteridosperm extinctions are concentrated in the Asturian, although some pulses of diversity loss are also observed at the end Bolsovian and middle Duckmantian, respectively (Fig. 7D, E).

## 6. Discussion

The Nord-Pas-de-Calais Coalfield macrofloras show an essentially skewed-unimodal pattern in species richness. This pattern is characterised by a sudden increase in the lowermost Westphalian, followed by a gradual growth during the Langsettian, peak values in the Duckmantian, but especially in Bolsovian, and a sharp decline in the Asturian (Fig. 6). Broadly similar diversity patterns have also been found in the macrofloras of the Westphalian coalfields in Britain and northern Germany (Cleal, 2005, 2007, 2008c; Uhl and Cleal, 2010; Fig. 8), but there are some differences, which throw light on the factors that were affecting the coal swamp vegetation at this time.

Namurian macrofloras in Nord-Pas-de-Calais are more diverse than those found in Britain (e.g., Lacey, 1952), but less than those of the Ruhr (e.g., Josten, 1983; Uhl and Cleal, 2010), probably reflecting the westwards retreat of marine influence across the Variscan Foreland. Most of the Variscan coalfields then show a similar, progressive increase in diversity through the Langsettian reaching about 60–80 species by the top of the substage. If the chronology of Davydov et al. (2010) and Waters and Condon (2012) of ca. 1.5 Myr for the Langsettian is accepted, we are seeing a new species appear every ca. 20–25 kyr. However, is this reflecting adaptive speciation, or migration of pre-existing and pre-adapted species into the new swamp

habitats? There were certainly areas of very comparable swamp vegetation in existence in early Namurian times, most notably in Upper Silesia (Poland and Czech Republic) and the Lower Loire (north-western France), although many of the species were different to those found in the lower Westphalian coal swamps (e.g., Bureau, 1914; Purkyňová, 1970; Strullu-Derrien et al., 2021). There are also macrofloras from the upper Namurian of Upper Silesia and the Ruhr, which include species that later appear in the Westphalian Nord-Pas-de-Calais macrofloras (Stopa, 1957; Josten, 1983), but there are other species (e.g., *Calymmotheca hoeninghausii* or *Neuropteris obliqua*) that do not seem to occur in these upper Namurian floras. This fossil record of the transition from late Namurian (proto coal swamp) to early Westphalian (full coal swamp) vegetation needs further investigation.

There are, however, differences in the dynamics of this Langsettian diversification of coal swamp vegetation between the different Variscan coalfields. For instance, in the Nord-Pas-de-Calais and Ruhr, species diversification is rapid, reaching over 60 species by the lower Modeste Member and lower Bochum Formation, respectively, and then slows down through the rest of the Langsettian (Fig. 8A, B). In the British coalfields, in contrast, diversification was initially slower, reaching levels of only ca. 20 species until the middle Langsettian, and then speeding up in the upper Langsettian (Fig. 8C, D). This may again be the result of delayed withdrawal of marine influence in the more western parts of the Variscan Foreland in Britain, reflected in the more-frequent marine bands followed by lacustrine deposits in the British lower and middle Langsettian (e.g., Evans et al., 2003) and this delayed the full development of the coal swamp biome here.

Across all the Variscan Foreland coalfields, macrofloral diversity tends to plateau in the Duckmantian, reaching values of 80–100 species in Nord-Pas-de-Calais and the Ruhr, but only about 60 species in the British coalfields (Fig. 8C–E). This lower diversity in the British coalfields is unlikely to be purely a sampling artefact: rarefaction analysis in South Wales showed that the samples were sufficiently large for this not to be an issue (Cleal, 2007; Cleal et al., 2012). It was also shown that a single horizon in the Central Pennine Basin (the Barnsley Main seam) showed a sharp peak in diversity that resembles the values seen in the Anzin Formation of Nord-Pas-

de-Calais and the Essen Formation of the Ruhr (Fig. 8A–C). This suggests that the coal swamp vegetation was more fully developed in the Nord-Pas-de-Calais and Ruhr compared with the one in Britain (other than the Barnsley Main seams floras). This discrepancy clearly needs a more detailed comparative taxonomic analysis.

In most of the Variscan coalfields, macrofloral diversity remains high in the lower Bolsovian (Fig. 7). The main exception is in the British Pennine Coalfields, where there is a major reduction in species numbers (Cleal, 2005, 2008c; Cleal et al., 2012) coinciding with a significant drying of substrates here and the development of red-beds known as the Etruria Formation (Besly and Turner, 1983; Turner et al., 1985; Besly and Fielding, 1989; Besly and Cleal, 1997). This drying of the substrates is unlikely to be due to global climatic change (full swamp conditions were prevailing further south in the Variscan foredeep such as in Nord-Pas-de-Calais) or to the northwards drift of Euramerica (Besly, 1986). Hence, we are likely seeing the results of a combination of reduced subsidence but continued sediment influx in these more northern cratonic areas. Whatever the causes, however, the result was a collapse of the coal swamp biome in the more northern cratonic areas, whilst it continued to flourish in the Variscan foredeep.

In Nord-Pas-de-Calais, in contrast, macrofloral diversity increases in the Bolsovian, mainly through larger numbers of non-marattialean fern taxa (Fig. 6), but no similar diversification is seen in Ruhr or South Wales (Fig. 8B, E). This diversification of ferns in the Six-Sillons Member (Fig. 7D) is associated with the development of numerous thick coal seams suggesting the coal swamp biome was especially well-developed at this time, but why this affected the ferns more than the other plant groups is unclear.

The Nord-Pas-de-Calais macrofloras undergo a substantial decline in diversity in the Asturian (Fig. 6). This cannot be explained as an edge-effect that often characterises diversity patterns at the top of stratigraphical sequences, and is merely a sampling artefact (Foote, 2000); the Dusouich Member in particular has numerous coal seams (Fig. 5) and the macrofloras were well-sampled as part of the work to delineate the Asturian Substage here (e.g., Laveine, 1977). A similar reduction in diversity also occurs in the lower Pennant Formation of South Wales (Cleal, 2007),

and the Lembeck Formation in the Ruhr (Uhl and Cleal, 2010), associated with an increase in coarse clastic sediment resulting from hinterland uplift caused by the northwards migration of the Variscan Front to the south (Jones, 1989; Gayer et al., 1993; Wrede and Ribbert, 2005; Wood et al., 2023). However, there is not an exact correlation between this diversity decline and the influx of coarse clastic sediment in the different areas; in Nord-Pas-de-Calais and the Ruhr the diversity change occurs before the change in sedimentation, whereas in South Wales the coarse-grained clastics appear first. This reduction in macrofloral diversity evidently needs further investigation into the distribution and taxonomy of the macrofloras in these different coalfields.

## 7. Conclusions

Macrofloral evidence indicates that the coal swamp vegetation in the Nord-Pas-de-Calais area followed a broadly similar diversity pattern during Namurian–Westphalian times to that seen in many other parts of the Variscan Foreland. The vegetation of this biome diversified more rapidly in Nord-Pas-de-Calais and the Ruhr compared with the British parts of the foreland, probably because marine incursions and lacustrine conditions delayed the full development of this biome in the latter areas until middle–late Langsettian times. The biome then flourished during Duckmantian times over much of the Variscan Foreland but went into decline during Bolsovian and Asturian times. This decline of the coal swamp biome started in Nord-Pas-de-Calais during Asturian times but elsewhere occurred earlier, in the early Bolsovian in the Pennine Basin, in the middle Bolsovian in the Ruhr, and in the late Bolsovian in South Wales. The evidence suggests that the collapse in plant diversity in the coal swamp biome was probably caused by changing substrate conditions due to increased sediment influx and reduced subsidence, resulting from the northwards migration of the Variscan Mountains. Further work is clearly needed on the detailed dynamics of the different macrofloral fossil-species in order to determine exactly how the various plant species of the coal swamp vegetation were responding to these ecological pressures. It will also be important to investigate further the relationship between the macrofloras of the lowland paralic basins such as Nord-Pas-de-Calais and of the

upland intramontane basins such as Saar-Lorraine and the Bohemia Massif, as this relationship seems to have played a key role in the overall evolution of the coal swamp vegetation during Westphalian times (e.g., see discussion in Thomas and Cleal, 2017; Cleal and Cascales-Miñana, 2019; Šimůnek and Cleal, 2020). Nevertheless, the new data presented here seem to confirm other studies in Europe (e.g., Cleal et al., 2009, 2011) that climate change was at most only a subsidiary factor in the collapse of the coal swamp biome.

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### **References**

- Becq-Giraudon, J.-F., 1983. Synthèse structurale et paléogéographique du bassin houiller du Nord et du Pas-de-Calais. Mémoires du Bureau de Recherches Géologiques et Minières 123, 1–67.
- Bertrand, P., 1914. Les zones végétales du terrain houiller du Nord de la France. Leur extension verticale par rapport aux horizons marins. Annales de la Société Géologique du Nord 43, 208–254.
- Bertrand, P., 1919. Les zones végétales du terrain houiller du Nord de la France. Comptes Rendus de l'Académie des Sciences, Paris 168, 780–782.
- Besly, B.M., 1986. Sedimentological evidence for Carboniferous and Early Permian palaeoclimates of Europe. Annales de la Société Géologique du Nord 106, 131–143.
- Besly, B.M., Cleal, C.J., 1997. Upper Carboniferous stratigraphy of the West Midlands (UK) revised in the light of borehole geophysical logs and detrital compositional suites. Geological Journal 32 (2), 85–118.

- Besly, B.M., Fielding, C.R., 1989. Palaeosols in Westphalian coal-bearing and red-bed sequences, central and northern England. *Palaeogeography, Palaeoclimatology, Palaeoecology* 70 (4), 303–330.
- Besly, B., Kelling, G., 1988. *Sedimentation in a Synorogenic Basin Complex: The Upper Carboniferous of Northwest Europe*. Blackie and Chapman & Hall, Glasgow and New York, 276 pp.
- Besly, B.M., Turner, P., 1983. Origin of red beds in a moist tropical climate (Etruria Formation, Upper Carboniferous, UK). Geological Society, London, Special Publications 11, 131–147.
- Bless, M.J.N., Bouckert, J., Calver, M.A., Graulich, J.M., Paproth, E., 1977. Palaeogeography of Upper Westphalian deposits in NW Europe with reference to the Westphalian C north of the mobile Variscan belt. *Mededelingen Rijks Geologische Dienst Nieuwe Serie* 28, 103–127.
- Boltovskoy, D., 1988. The range-through method and first-last appearance data in paleontological surveys. *Journal of Paleontology* 62 (1), 157–159.
- Boulay, N., 1876. *Le terrain houiller du Nord de la France et ses végétaux fossiles*. Thèse, Faculté des Sciences, Caen, 74 pp.
- Bouroz, A., 1960a. Sur les subdivisions du terrain houiller du Nord de la France. *Comptes Rendus de l'Académie des Sciences, Paris* 251, 2050–2052.
- Bouroz, A., 1960b. Le niveau marin de Wingles dans le Westphalien B du Pas-de-Calais. *Bulletin de la Société Géologique de France* S7-II, 540–545.
- Bouroz, A., 1967. Corrélation des tonsteins d'origine volcanique entre les bassins houillers de Sarre-Lorraine et du Nord-Pas-de-Calais. *Comptes Rendus de l'Académie des Sciences, Paris* 264, 2729–2732.
- Bouroz, A., 1969. Le Carbonifère du Nord de la France. *Annales de la Société Géologique du Nord* 89, 47–65.
- Bouroz, A., Stievenard, H., Buisine, A., Dalinval, A., Dollé, P., Pinnel, G., Puirabord, G., 1963. Carte des zones stratigraphique à la côte stratigraphique - 300 m du Bassin Houiller du Nord et du Pas de Calais. Service de Ressources et Études Géologiques des HBNPC, Institut Géographique National, Paris.

- Brongniart, A., 1828. Prodrome d'une Histoire des végétaux fossiles. Dictionnaire des Sciences Naturelles 57, 1–223.
- Buisine, A., 1961. Contribution a l'étude de la flore du terrain houiller. Les Aléthoptéridées du Nord de la France. Études Géologiques pour l'Atlas Topographie Souterraine 1 (4), 1–317.
- Bureau, É., 1914. Bassin houiller de la Basse Loire. Fascicule II. Description des flores fossiles. Études des Gîtes Minéraux de la France, Paris, 355 pp.
- Capel, E., Cleal, C.J., Xue, J., Monnet, C., Servais, T., Cascales-Miñana, B., 2022. The Silurian–Devonian terrestrial revolution: Diversity patterns and sampling bias of the vascular plant macrofossil record. Earth-Science Reviews 231, 104085.
- Carpentier, A., 1913. Contribution à l'Étude du Carbonifère du Nord de la France. Thèse, Faculté des Sciences, Lille, 458 pp.
- Cascales-Miñana, B., Cleal, C.J., Diez, J.B., 2013. What is the best way to measure extinction? A reflection from the palaeobotanical record. Earth-Science Reviews 124, 126–147.
- Chalard, J., 1960. Contribution à l'étude du Namurien du bassin houiller du Nord de la France. Études Géologiques pour l'Atlas Topographie Souterraine 3 (1), 1–299.
- Cleal, C.J., 2005. The Westphalian macrofloral record from the cratonic central Pennines Basin, UK. Zeitschrift der Deutschen Gesellschaft für Geowissenschaften 156, 387–402.
- Cleal, C.J., 2007. The Westphalian–Stephanian macrofloral record from the South Wales Coalfield, UK. Geological Magazine 144 (3), 465–486.
- Cleal, C.J., 2008a. Palaeofloristics of Middle Pennsylvanian lyginopteridaleans in Variscan Euramerica. Palaeogeography, Palaeoclimatology, Palaeoecology 261 (1–2), 1–14.
- Cleal, C.J., 2008b. Palaeofloristics of Middle Pennsylvanian medullosaleans in Variscan Euramerica. Palaeogeography, Palaeoclimatology, Palaeoecology 268 (3–4), 164–180.

- Cleal, C.J., 2008c. Westphalian–Stephanian macrofloras of the Southern Pennines Basin, UK. *Studia Geologica Polonica* 129, 25–41.
- Cleal, C.J., 2018. The Carboniferous coal swamp floras of England: a window on an ancient tropical ecosystem. *Proceedings of the Geologists' Association* 129 (3), 329–351.
- Cleal, C.J., Cascales-Miñana, B., 2019. The floristic relationship between the upland and lowland Carboniferous wetlands of Variscan Euramerica — Evidence from some medullosalean pteridosperm fronds. *Journal of Palaeogeography* 8 (2), 130–141.
- Cleal, C.J., Thomas, B.A., 2005. Palaeozoic tropical rainforests and their effect on global climates: is the past the key to the present? *Geobiology* 3, 13–31.
- Cleal, C.J., Tenchov, Y., Dimitrova, T., Thomas, B.A., Zodrow, E.L., 2007. Late Westphalian–Early Stephanian vegetational changes across the Variscan Foreland. In: Wong, T.E. (Ed.), *Proceedings of the XVth International Congress on Carboniferous and Permian Stratigraphy*. Royal Netherlands Academy of Arts and Sciences, Amsterdam, pp. 367–377.
- Cleal, C.J., Opluštil, S., Thomas, B.A., Tenchov, Y., Abbink, O.A., Bek, J., Dimitrova, T., Drábková, J., Hartkopf-Fröder, C., Hoof, T. van, Kędzior, A., Jarzembowski, E., Jasper, K., Libertin, M., McLean, D., Oliwkiewicz-Miklasinska, M., Pšenička, J., Ptak, B., Schneider, J.W., Schultka, S., Šimůnek, Z., Uhl, D., Waksmundzka, M.I., Waveren, I. van, Zodrow, E.L., 2009. Late Moscovian terrestrial biotas and palaeoenvironments of Variscan Euramerica. *Netherlands Journal of Geosciences* 88, 181–278.
- Cleal, C.J., Opluštil, S., Thomas, B.A., Tenchov, Y., 2011. Pennsylvanian vegetation and climate in tropical Variscan Euramerica. *Episodes* 34 (1), 3–12.
- Cleal, C.J., Uhl, D., Cascales-Miñana, B., Thomas, B.A., Bashforth, A.R., King, S.C., Zodrow, E.L., 2012. Plant biodiversity changes in Carboniferous tropical wetlands. *Earth-Science Reviews* 114 (1–2), 124–155.
- Cohen, K.M., Finney, S.C., Gibbard, P.L., Fan, J.-X., 2013. The ICS International Chronostratigraphic Chart. *Episodes* 36 (3), 199–204.



- Corsin, P., Corsin, P., 1970. Un siècle et demi de Paléobotanique dans le Nord de la France. *Annales de la Société Géologique du Nord* 90, 223–252.
- Corsin, P., Corsin, P., 1971. Zonation biostratigraphique du Houiller des bassins du Nord-Pas-de-Calais et de Lorraine. *Comptes Rendus de l'Académie des Sciences, Paris* 273, 783–788.
- DalINVAL, A., 1960. Contribution à l'étude des Pécoptéridées. Les *Pecopteris* du Bassin Houiller du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (3), 1–222.
- Danzé, J., 1956. Contribution à l'étude des *Sphenopteris*. Les fougères Sphénoptéridiennes du bassin houiller du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (2), 1–568.
- Danzé-Corsin, P., 1953. Contribution à l'étude des Marioptéridées. Les *Mariopteris* du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (1), 1–269.
- Davydov, V.I., Crowley, J.L., Schmitz, M.D., Poletaev, V.I., 2010. High-precision U-Pb zircon age calibration of the global Carboniferous time scale and Milankovitch band cyclicity in the Donets Basin, eastern Ukraine. *Geochemistry, Geophysics, Geosystems* 11 (2), Q0AA04.
- DiMichele, W.A., 2014. Wetland-dryland vegetational dynamics in the Pennsylvanian Ice Age tropics. *International Journal of Plant Sciences* 175 (2), 123–164.
- DiMichele, W.A., Stein, W.E., Bateman, R.M., 2001. Ecological sorting of vascular plant classes during the Paleozoic evolutionary radiation. In: Allmon, W.D., Bottjer, J.D. (Eds.), *Evolutionary Paleocology*. Columbia University Press, New York, pp. 285–336.
- Dollé, P., 1958. Étude préliminaire sur les grès du bassin houiller du Nord et du Pas-de-Calais. *Eclogae Geologicae Helveticae* 51, 917–928.
- Evans, B.G., Cleal, C.J., Thomas, B.A., Wimbledon, W.A.P., 2003. The Westphalian succession of the Glyn-neath area, South Wales: an internationally important geological resource. *Proceedings of the Geologists' Association* 114 (4), 291–305.

- Fielding, C.R., Frank, T.D., Birgenheier, L.P., Rygel, M.C., Jones, A.T., Roberts, J., 2008. Stratigraphic imprint of the Late Palaeozoic Ice Age in eastern Australia: a record of alternating glacial and nonglacial climate regime. *Journal of the Geological Society, London* 165, 129–140.
- Foote, M., 2000. Origination and extinction components of taxonomic diversity: General problems. *Paleobiology* 26 (4), 74–102.
- Gayer, R.A., Cole, J.E., Greiling, R.O., Hecht, C., Jones, J.A., Vogel, A.K., 1993. Comparative evolution of coal-bearing foreland basins along the Variscan northern margin in Europe. In: Gayer, R.A., Greiling, R.O., Vogel, A.K. (Eds.), *Renohercynian and Subvariscan Fold Belts*. Vieweg and Sons, Braunschweig, pp. 47–82.
- Guéguen, Y., Deffontaines, B., Fruneau, B., Al Heib, M., de Michele, M., Raucoules, D., Guise, Y., Planchenault, J., 2009. Monitoring residual mining subsidence of Nord/Pas-de-Calais coal basin from differential and Persistent Scatterer Interferometry (Northern France). *Journal of Applied Geophysics* 69 (1), 24–34.
- Jones, J.A., 1989. The influence of contemporaneous tectonic activity on Westphalian sedimentation in the South Wales Coalfield. *Occasional Publications of the Yorkshire Geological Society* 6, 243–253.
- Josten, K.-H., 1983. Die fossilen floren im Namur des Ruhrkarbons. *Fortschritte in der Geologie von Rheinland und Westfalen* 31, 1–327.
- Knight, J.A., Cleal, C.J., Álvarez-Vázquez, C., 2023. The challenge of relating the Kasimovian to West European chronostratigraphy — a critical review of the Cantabrian and Barruelian substages of the Stephanian Stage. *Geological Society, London, Special Publications* 535, doi: 10.1144/SP535-2022-189.
- Lacey, W.S., 1952. Additions to the Millstone Grit flora of Lancashire. *Troisième Congrès pour l'avancement des études de Stratigraphie et de Géologie du Carbonifère*. Heerlen, Pays-Bas, pp. 379–383.
- Laurent, A., Averbuch, O., Beccaletto, L., Graveleau, F., Lacquement, F., Capar, L., Marc, S., 2021. 3-D Structure of the Variscan Thrust front in northern France: New insights from seismic reflection profiles. *Tectonics* 40, e2020TC006642.

- Laveine, J.-P., 1967. Contribution à l'étude de la flore du terrain houiller. Les Neuroptéridées du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (5), 1–344.
- Laveine, J.-P., 1977. Report on the Westphalian D. In: Holub, V.M., Wagner, R.H. (Eds.), *Symposium on Carboniferous Stratigraphy*. Geological Survey, Prague, pp. 71–83.
- Laveine, J.-P., 1987. La flore du bassin houiller du Nord de la France, Biostratigraphie et méthodologie. *Annales de la Société Géologique du Nord* 106, 87–93.
- Laveine, J.-P., Belhis, A., 2007. Frond architecture of the seed-fern *Macroneuropteris scheuchzeri*, based on Pennsylvanian specimens from the Northern France coal field. *Palaeontographica Abteilung B* 277, 1–41.
- Laveine, J.-P., Goubet, P., 1995. Mise au point sur *Palaeoweichselia defrancei* (ptéridospermée du Carbonifère), à partir d'un bel échantillon récolté dans le bassin houiller du nord de la France. *Sciences Géologiques, Bulletins et Mémoires* 48, 21–47.
- Laveine, J.-P., Coquel, R., Brousmiche, C., 1978. L'espece *Pecopteris simoni* (Zeiller, 1886–1888) synonyme postérieur de *Palaeoweichselia defrancei* (Brongniart, 1828). *Geobios* 11 (5), 755–759.
- Magurran, A.E., 2013. *Measuring Biological Diversity*. John Wiley & Sons, London, 272 pp.
- Montañez, I.P., Poulsen, C.J., 2013. The Late Paleozoic Ice Age: An evolving paradigm. *Annual Review of Earth and Planetary Sciences* 41, 629–656.
- Opluštil, S., Cleal, C.J., 2007. A comparative analysis of some Late Carboniferous basins of Variscan Europe. *Geological Magazine* 144 (3), 417–448.
- Opluštil, S., Schneider, J.W., 2023. Middle–Late Pennsylvanian tectonosedimentary, climatic and biotic records in basins of Europe, NW Turkey and North Africa: an overview. Geological Society, London, Special Publications 535, doi: 10.1144/SP535-2022-215.
- Opluštil, S., Schmitz, M., Cleal, C.J., Martínek, K., 2016. A review of the Middle–Late Pennsylvanian west European regional substages and floral biozones, and

- their correlation to the Geological Time Scale based on new U–Pb ages. *Earth-Science Reviews* 154, 301–335.
- Opluštil, S., Šimůnek, Z., Pšenička, J., Bek, J., Libertín, M., 2017. A 25 million year macrofloral record (Carboniferous–Permian) in the Czech part of the Intra-Sudetic Basin; biostratigraphy, plant diversity and vegetation patterns. *Review of Palaeobotany and Palynology* 244, 241–273.
- Owens, B., Riley, N.J., Calver, M.A., 1985. Boundary stratotypes and new stage names for the lower and middle Westphalian sequences in Britain. *Compte rendu 9e Congrès International de Stratigraphie et de Géologie du Carbonifère (Madrid, 1983)* 4, 461–472.
- Purkyňová, E., 1970. Die Unternamurflora des Beckens von Horní Slezsko (CSSR). *Paläontologische Abhandlungen, Abteilung B* 3, 129–268.
- Šimůnek, Z., Cleal, C.J., 2020. A synopsis of Westphalian–earliest Stephanian medullosalean and allied plant fossils from the Central and Western Bohemian basins, Czech Republic. *Bulletin of Geosciences* 95 (4), 441–468.
- Stopa, S.Z., 1957. Rośliny paprociolistne (Pteridophylla) górnego namuru i najniższego westfalu na Górnym Śląsku, *Prace Instytut Geologiczny. Wydawn. Geologiczne, Warszawa*, 208 pp.
- Strullu-Derrien, C., Cleal, C.J., Ducassou, C., Spencer, A.R.T., Stolle, E., Leshyk, V.O., 2021. A rare late Mississippian flora from Northwestern Europe (Maine-et-Loire Coalfield, Pays de la Loire, France). *Review of Palaeobotany and Palynology* 285, 104359.
- Thomas, B.A., Cleal, C.J., 2017. Distinguishing Pennsylvanian-age lowland, extra-basinal and upland vegetation. *Palaeobiodiversity and Palaeoenvironments* 97, 273–293.
- Turner, P., Vaughan, D.J., Besly, B., 1985. Remanence acquisition in red beds from the Coal Measures of Central England. *Journal of the Geological Society* 142, 1015–1028.
- Uhl, D., Cleal, C.J., 2010. Late Carboniferous vegetation change in lowland and intramontane basins in Germany. *International Journal of Coal Geology* 83 (2–3), 318–328.

- Wagner, R.H., 1974. The chronostratigraphic units of the Upper Carboniferous in Europe. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie* 83, 235–253.
- Wagner, R.H., 2017. The 'global' scheme of Pennsylvanian chronostratigraphic units contrasted with the West European and North American regional classifications: discussion of paleogeographic zones/regions and problems of correlation. *Stratigraphy* 14 (1–4), 405–423.
- Wagner, R.H., Winkler Prins, C.F., 2016. History and current status of the Pennsylvanian chronostratigraphic units: problems of definition and interregional correlation. *Newsletters on Stratigraphy* 49 (2), 281–320.
- Warnock, R.C.M., Heath, T.A., Stadler, T., 2020. Assessing the impact of incomplete species sampling on estimates of speciation and extinction rates. *Paleobiology* 46 (2), 137–157.
- Waters, C.N., Condon, D.J., 2012. Nature and timing of Late Mississippian to Mid-Pennsylvanian glacio-eustatic sea-level changes of the Pennine Basin, UK. *Journal of the Geological Society* 169, 37–51.
- Wood, J., McLeod, J.S., Lyster, S.J., Whittaker, A.C., 2023. Rivers of the Variscan Foreland: fluvial morphodynamics in the Pennant Formation of South Wales, UK. *Journal of the Geological Society, London* 180 (1), doi: 10.1144/jgs2022-048.
- Wrede, V., Ribbert, K., 2005. Das Oberkarbon (Silesium) am Nordrand des rechtsrheinischen Schiefergebirges (Ruhrkarbon). *Courier-Forschungsinstitut Senckenberg* 254, 225–254.
- Zeiller, R., 1888. Bassin houiller de Valenciennes: description de la flore fossile. *Études des Gîtes Minéraux de la France*, Paris, 731 pp.

## Figure captions

Fig. 1. Geographic position of the Nord-Pas-de-Calais Coalfield. (A) Map of North France showing distribution of the Upper Carboniferous (Namurian–Westphalian) outcrops (modified from Bouroz, 1969, fig. 1); dotted line highlights the study area. (B) Map of Nord-Pas-de-Calais Coalfield showing distribution of stratigraphical zones (modified from Bouroz, 1969, fig. 6 and Guéguen et al., 2009, fig. 2); lithological data according to Bouroz et al. (1963). Mining concessions: (1) Fléchinelle, (2) Auchy-au-Bois, (3) Ferfay, (4) Marles, (5) Cauchy-à-la-Tour, (6) Camblain-Chatelain, (7) Bruay, (8) Beugin, (9) Vendin, (10) Noeux, (11) Fresnicourt, (12) Grenay, (13) Gouy-Servins, (14) Douvrin, (15) Ablain-Saint-Nazaire, (16) Liévin, (17) Lens, (18) Meurchin, (19) Vimy-Fresnoy, (20) Drocourt, (21) Courrières, (22) Carvin, (23) Dourges, (24) Ostricourt, (25) Courcelles-lez-Lens, (26) Escarpelle, (27) Aniche, (28) Flines-lez-Raches, (29) Azincourt, (30) Anzin, (31) Douchy, (32) Denain, (33) Hasnon, (34) Vicoigne, (35) Raismes, (36) Marly, (37) Saint-Saulve, (38) Crespin, (39) Thivencelle, (40) Escaupont, (41) Fresnes, (42) Odomez, (43) Bruille, (44) Château l'Abbaye, (45) Vieux-Condé, (46) Saint-Aybert.

Fig. 2. Namurian–Westphalian stratigraphy of the Nord-Pas-de-Calais Coalfield, based on successions in Marles, Béthune, Douai and Valenciennes areas, including massif of Douvrin, Bruay-Len and Dorignies-Denain. Based on data in Becq-Giraudon (1983, fig. 7).

Fig. 3. Stratigraphic divisions of the Nord-Pas-de-Calais Coalfield (Bouroz, 1960a, 1969).

Fig. 4. Synthetic column of Namurian lithostratigraphy of the Nord-Pas-de-Calais Coalfield. Raw data based on successions in Douai and Valenciennes areas. Modified from Bouroz (1969, fig. 4).

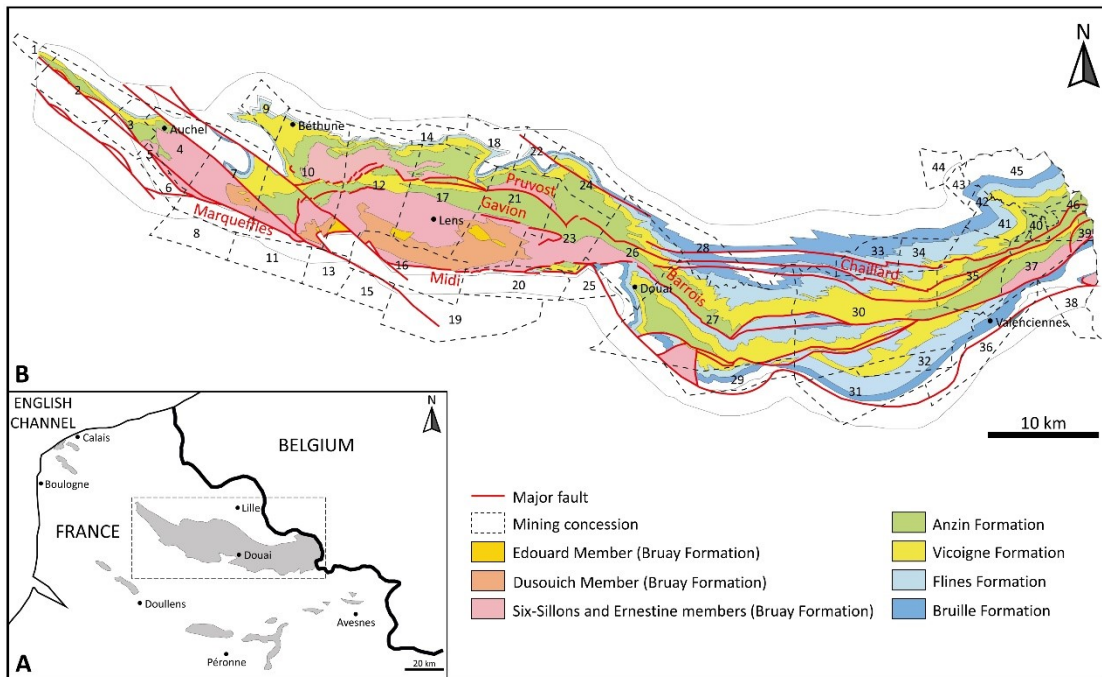
Fig. 5. Synthetic column of Westphalian lithostratigraphy of the Nord-Pas-de-Calais Coalfield. Legend as same in Fig. 4.

Fig. 6. Dynamics of total species richness in the macrofloral record through the Nord-Pas-de-Calais Coalfield. Stratigraphy is based on a standardised succession following Figs. 4, 5. Asterisk indicates Olympe Member. Raw data are given in Table S1.

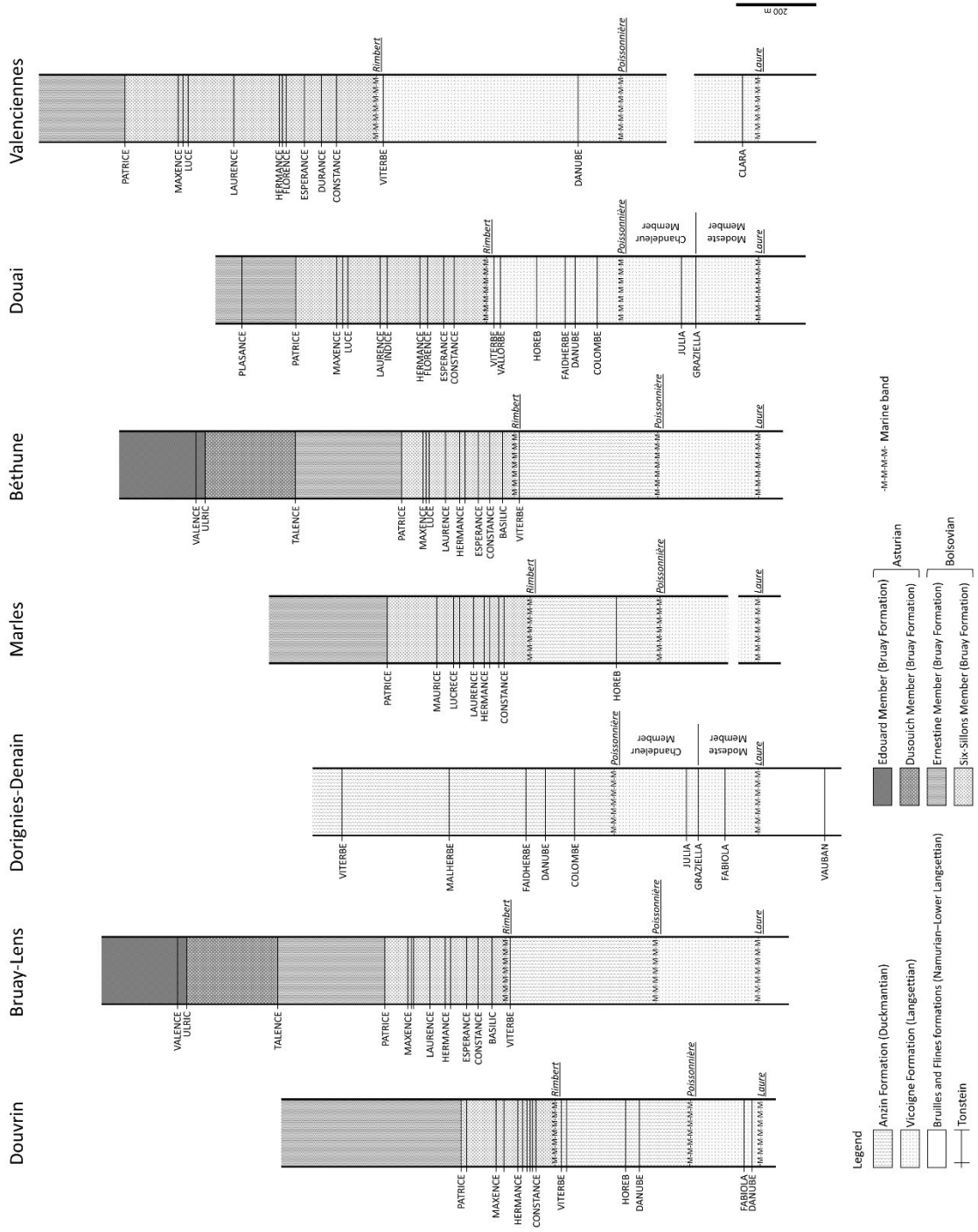
Abbreviations: Arns., Arnsbergian; Chock., Chokierian.

Fig. 7. Per-capita origination-extinction rate values ( $L_{my}$ ) observed in the Nord-Pas-de-Calais Coalfield macrofloras. Legend as same in Fig. 6.

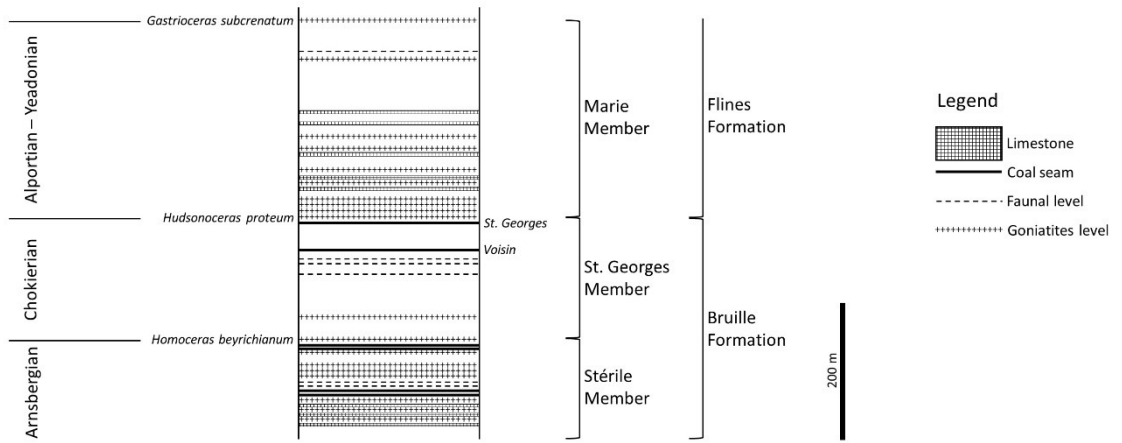
Fig. 8. Comparison of species diversity dynamics through Westphalian times in different coalfields of the Variscan Foreland. Based on Cleal (2005, 2007, 2008c), Uhl and Cleal (2010) and the present paper.

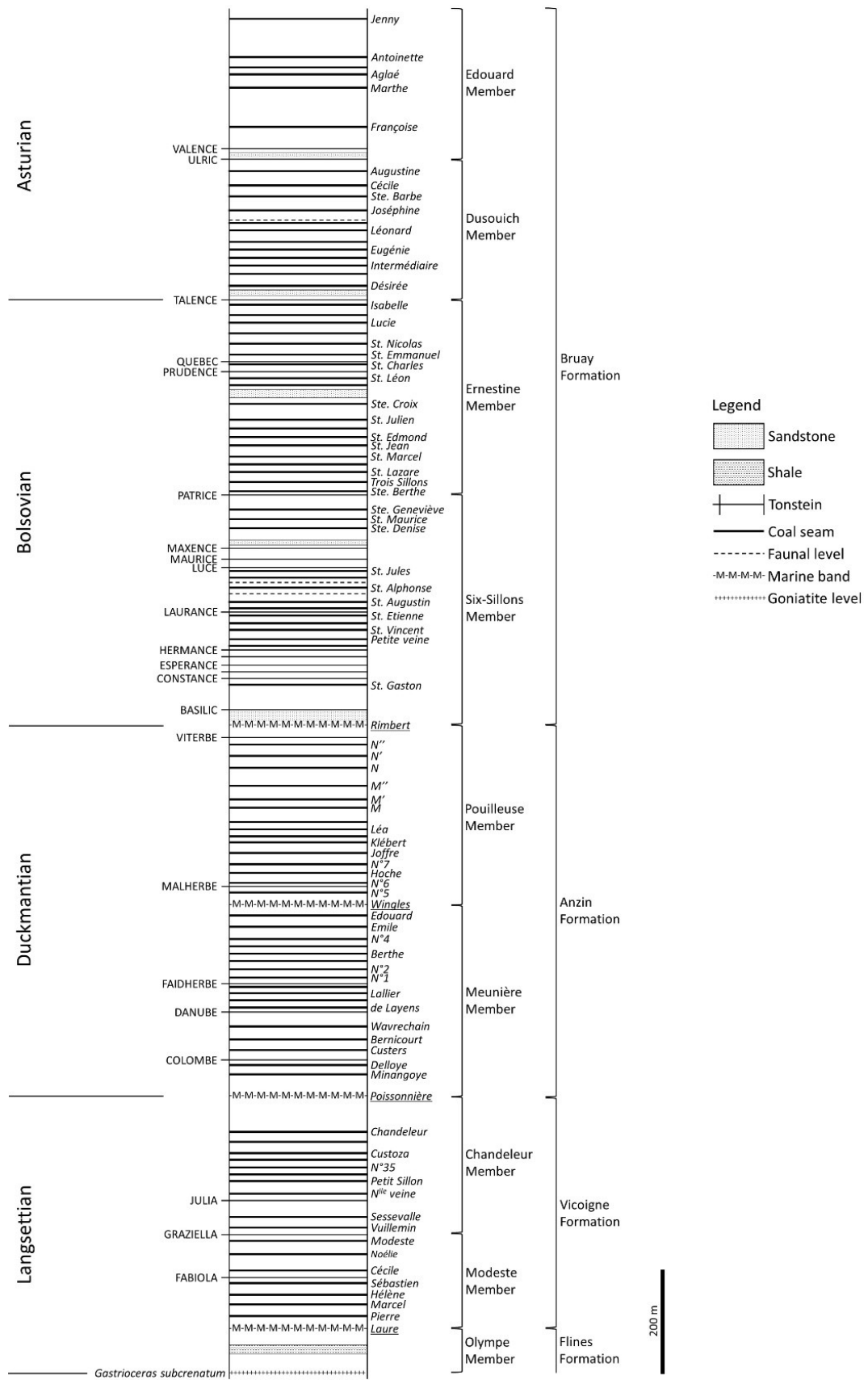


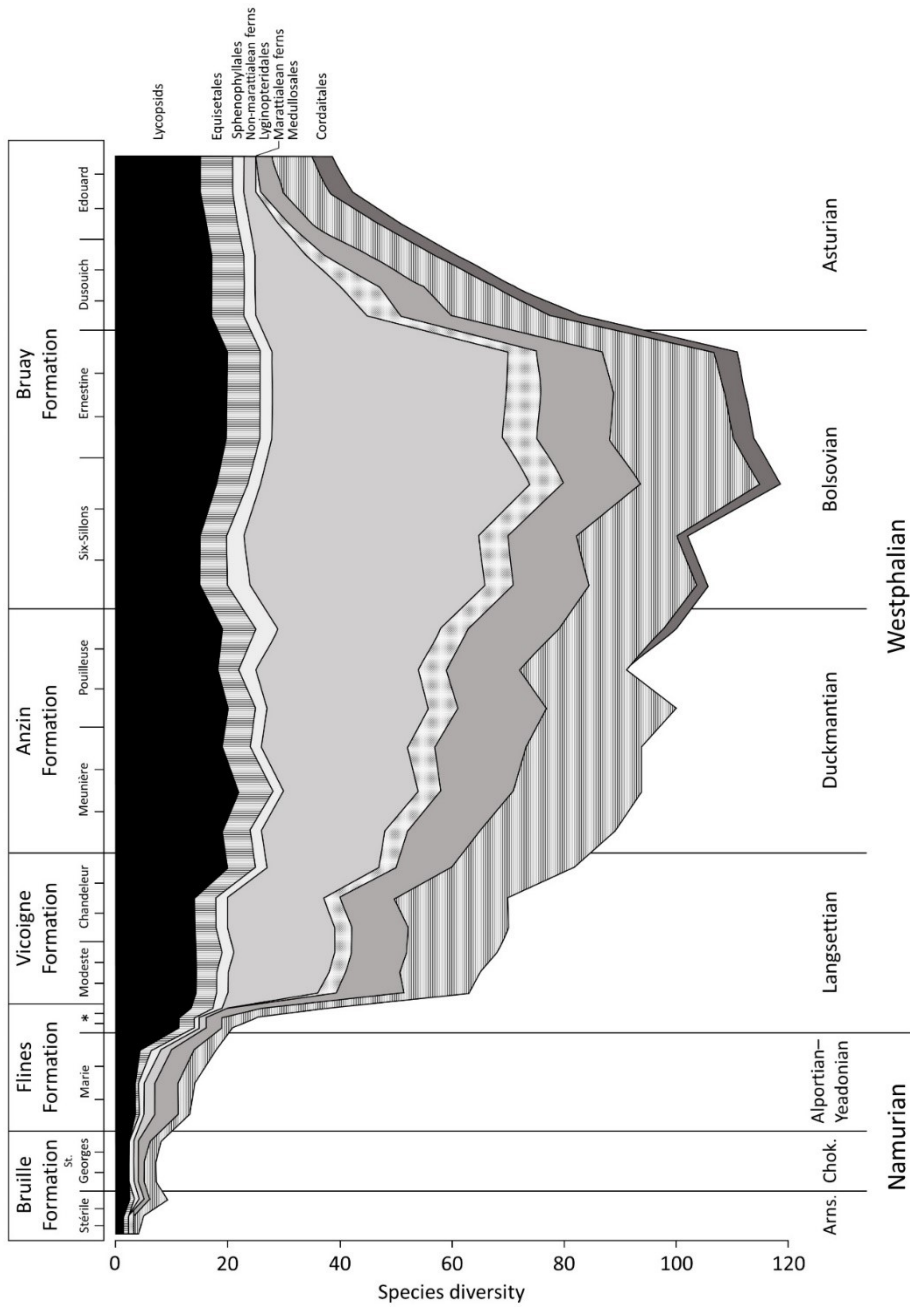


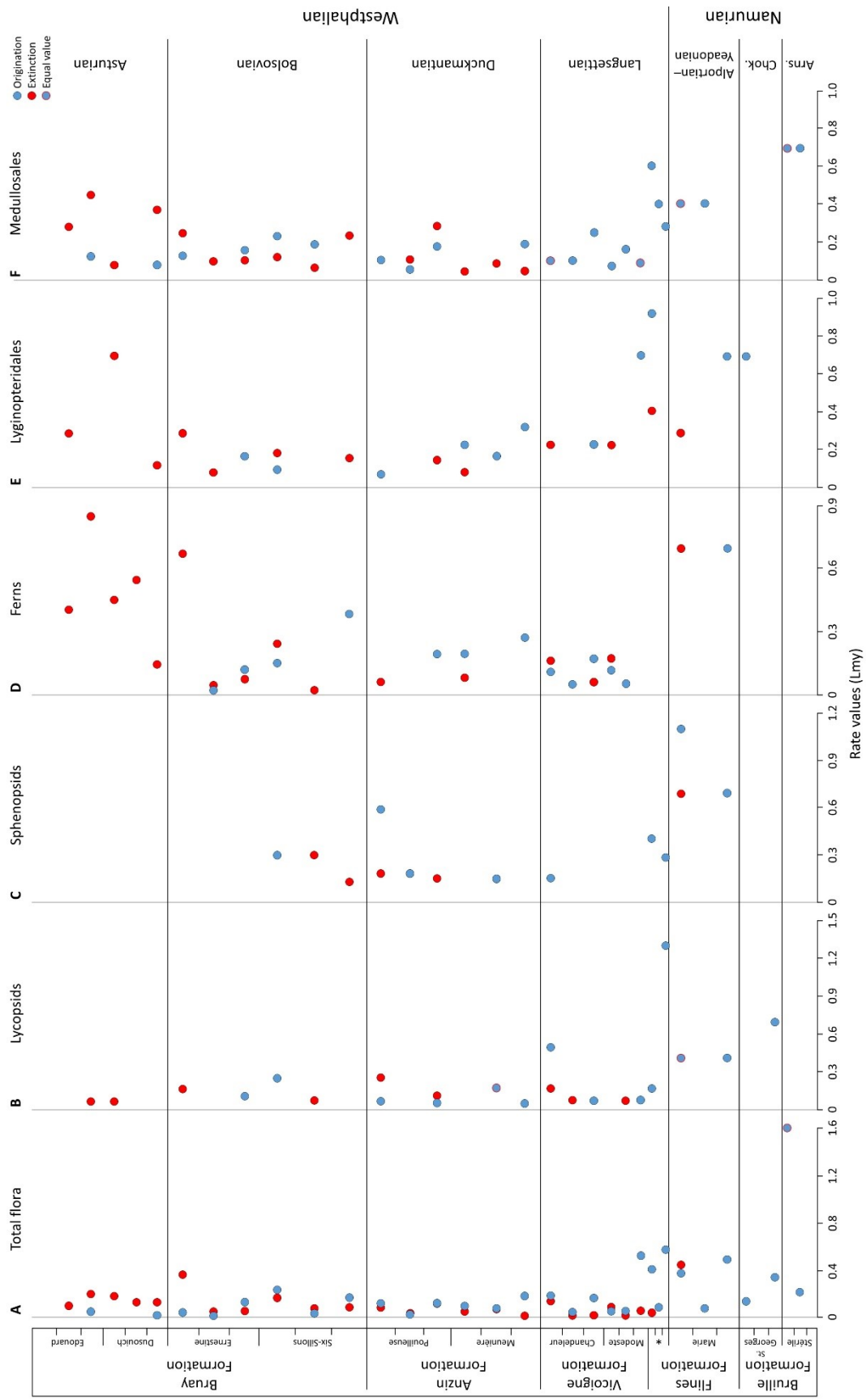


Substage	Formation	Member
Asturian	Bruay	Edouard
		Dusouich
Bolsovian		Ernestine
		Six-Sillons
Duckmantian	Anzin	Pouilleuse
		Meunière
Langsettian	Vicoigne	Chandeleur
	Flines	Modeste
Olympe		
Alportian–Yeadonian		Marie
Chokierian	Bruille	St. Georges
Arnsbergian		Stérile









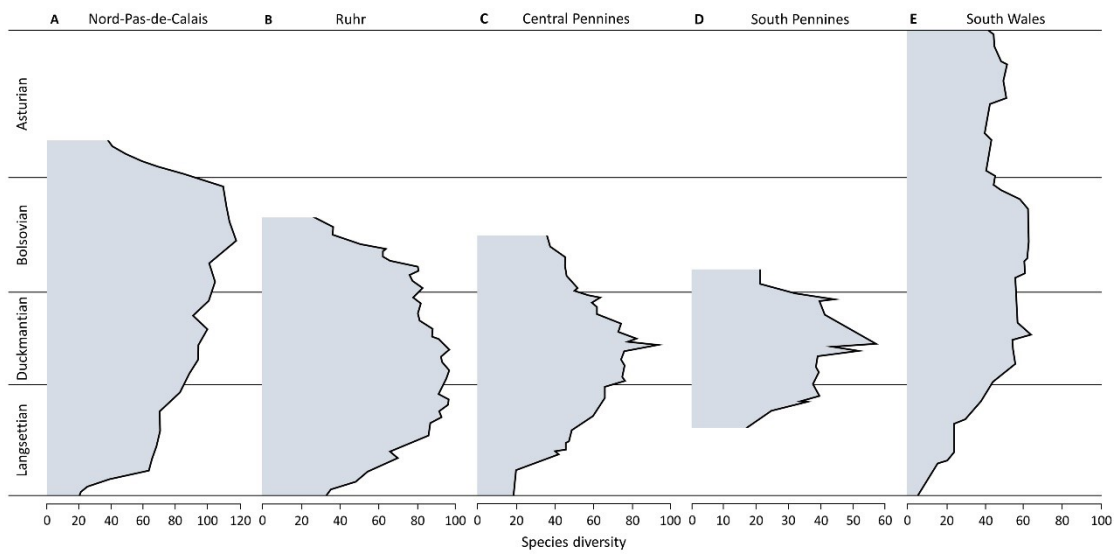


Table S1. Species diversity of plant macrofossils from the Nord-Pas-de-Calais Coalfield. For each taxon, the plant group to which it belongs, as well as its first and last appearance (i.e., FAD and LAD, respectively) in the basin are provided. Compiled fossil sites, when available, are justificative of exposed range only. NA: Not available.

Taxon	Plant group	Temporal distribution				Reference
		FAD	Fossil site	LAD	Fossil site	
<i>Alethopteris bertrandii</i> Bouroz (= <i>Alethopteris michauxii</i> Buisine - vide Cleal, 2008b)	Medullosales	Six-Sillons Member (Upper)	Béthune, pit N° 3, coal seam undetermined	Dusouich Member (Upper)	Lens, pit N° 3, Théodore	Buisine (1961, pp. 137–138)
<i>Alethopteris corsinii</i> Buisine (= <i>Alethopteris hermetetii</i> Buisine - vide Cleal, 2008b)	Medullosales	Pouilleuse Member (Middle)	Noeux, pit N° 3, coal seam N° 1	Dusouich Member (Lower)	Béthune, pit N° 5, St. Symphorien	Buisine (1961, pp. 123, 184)
<i>Alethopteris davreuxii</i> (Brongniart) Zeiller	Medullosales	Olympe Member (Upper)	Douai, pit Notre-Dame, coal seam N° 28	Dusouich Member (Lower)	Lens, pit N° 4, coal seam undetermined	Buisine (1961, pp. 152–153)
<i>Alethopteris decurrens</i> (Artis) Zeiller	Medullosales	Olympe Member (Lower)	Escarpelle, pit N° 5, coal seam undetermined	Dusouich Member (Lower)	Liévin, pit N° 5, coal seam undetermined	Buisine (1961, pp. 164, 166)
<i>Alethopteris densinervosa</i> Wagner (= <i>Alethopteris serlii</i> (Brongniart) Göppert - vide Wagner and Álvarez-Vázquez, 2008)	Medullosales	Pouilleuse Member (Lower)	Escarpelle, pit N° 10, coal seam undetermined	Edouard Member (Lower)	Lens, pit N° 3, François	Buisine (1961, pp. 93, 97)
<i>Alethopteris cf. grandinii</i> (Brongniart) Göppert	Medullosales	Meunière Member (Lower)	Valenciennes, pit Cuvinot, coal seam undetermined	Edouard Member (Upper)	Undetermined	Buisine (1961, p. 198); Laveine (1987, p. 89)
<i>Alethopteris pontica</i> Zeiller	Medullosales	Ernestine Member (Upper)	Courrières, pit N° 21, Brillante	Edouard Member (Lower)	Lens, pit N° 3, François	Buisine (1961, pp. 204–205)
<i>Alethopteris urophylla</i> (Brongniart) Göppert (= <i>Alethopteris lonchitica</i> (Schlotheim) Zeiller - vide Wagner and Álvarez-Vázquez, 2008)	Medullosales	Marie Member (Upper)	Undetermined	Six-Sillons Member (Lower)	Lens, pit N° 6, coal seam N° 20	Buisine (1961, p. 114); Laveine (1987, p. 89)
<i>Alethopteris valida</i> Boulay	Medullosales	Olympe Member (Upper)	Lens, pit N° 7, coal seam undetermined	Pouilleuse Member (Lower)	Douai, pit St. René, coal seam N° 6	Buisine (1961, p. 177)
<i>Annularia microphylla</i> Sauveur	Equisetales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Annularia radiata</i> (Brongniart) Sternberg	Equisetales	Marie Member (Upper)	Undetermined	Pouilleuse Member (Middle)	Undetermined	Laveine (1987, p. 89)
<i>Annularia sphenophylloides</i> (Zenker) Gutbier	Equisetales	Pouilleuse Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Annularia stellata</i> (Schlotheim) Wood	Equisetales	Pouilleuse Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Archaeocalamites radiatus</i> Brongniart	Equisetales	Stérile Member (Lower)	Undetermined	Stérile Member (Upper)	Undetermined	Corsin (1962, p. 1); Corsin and Corsin (1970, p. 241)
<i>Asolanus camptotaenia</i> Wood	Lycopsids	Pouilleuse Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Corsin (1962, p. 4); Corsin and Corsin (1970, pp. 243–244)
<i>Asterophyllites charaeformis</i> (Sternberg) Göppert	Equisetales	Modeste Member (Upper)	Douai, pit St. René, Modeste	NA	NA	Bertrand (1914, p. 219); Bouroz (1969, p. 52)



Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Asterophyllites equisetiformis</i> Brongniart	Equisetales	Meunière Member (Middle)	Douai, pit Notre-Dame, coal seam N° 2	Pouilleuse Member (Lower)	Douai, pit Notre-Dame, coal seam N° 7	Bertrand (1914, pp. 225–226)
<i>Asterophyllites grandis</i> (Sternberg) Lindley and Hutton	Equisetales	Olympe Member (Upper)	Douai, pit Notre-Dame, Olympe	Meunière Member (Middle)	Douai, pit Notre-Dame, coal seam N° 2	Bertrand (1914, pp. 215, 225)
<i>Asterophyllites longifolius</i> (Sternberg) Lindley and Hutton	Equisetales	Marie Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232, 243)
<i>Asterophyllites lycopodioides</i> Zeiller	Equisetales	Pouilleuse Member (Upper)	Undetermined	Six-Sillons Member (Middle)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Bothrodendron minutifolium</i> Boulay	Lycopsids	Olympe Member (Lower)	Undetermined	Six-Sillons Member (Middle)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Bothrodendron punctatum</i> Lindley and Hutton	Lycopsids	Olympe Member (Upper)	Douai, pit St. Marie, Petite veine	Meunière Member (Middle)	Douai, pit Notre-Dame, Déjardin	Bertrand (1914, pp. 221, 225)
<i>Boweria schatzlarensis</i> (Stur) Kidston	Non-marattialean ferns	Pouilleuse Member (Lower)	Bruay, pit N° 5, coal seam N° 38	Six-Sillons Member (Upper)	Valenciennes, pit Crespin, coal seam undetermined	Danzé (1956, p. 370)
<i>Calamophyllites goeppertii</i> Ettingshausen	Equisetales	Chandeleur Member (Upper)	Undetermined	Pouilleuse Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Calamophyllites verticillatus</i> Lindley and Hutton	Equisetales	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Calymmatotheca hoeninghausii</i> Stur	Lyginopteridales	Marie Member (Lower)	Undetermined	Chandeleur Member (Upper)	Undetermined	Corsin and Corsin (1970, p. 243); Laveine (1987, p. 89)
<i>Cardiocarpus boulayi</i> Zeiller	Cordaitales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Cardioneuropteris antecedens</i> (Stur) Strullu-Derrien et al.	Medullosales	Stérile Member (Lower)	Undetermined	Stérile Member (Upper)	Undetermined	Corsin (1962, p. 1); Corsin and Corsin (1970, p. 241)
<i>Carpolithes perpusillus</i> Lesquereux	Cordaitales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Cirossotheca bourozii</i> Danzé	Non-marattialean ferns	Pouilleuse Member (Lower)	Aniche, pit Dechy, coal seam N° 3	Six-Sillons Member (Upper)	Crespin, pit N° 2, coal seam F	Danzé (1956, p. 360)
<i>Cordaianthus volkmannii</i> Ettingshausen	Cordaitales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Cordaicarpus areolatus</i> Boulay	Cordaitales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Cordaicarpus cordai</i> (Geinitz) Seward	Cordaitales	Pouilleuse Member (Upper)	Undetermined	Six-Sillons Member (Middle)	Undetermined	Zeiller (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Corynepteris angustissima</i> (Sternberg) Kidston (= <i>Corynepteris sternbergii</i> Ettingshausen - vide Brousmiche, 1983)	Non-marattialean ferns	Modeste Member (Lower)	Undetermined	Ernestine Member (Upper)	Bruay, pit N° 3, coal seam N° 6	Danzé (1956, pp. 330–331); Loboziak (1971, p. 92–93)
<i>Corynepteris coralloides</i> Gutbier	Non-marattialean ferns	Modeste Member (Lower)	Lens, pit N° 13, coal seam undetermined	Dusouich Member (Upper)	Undetermined	Danzé (1956, p. 315); Laveine (1987, p. 89)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Corynepteris</i> cf. <i>crystata</i> Gutbier	Non-marattialean ferns	Six-Sillons Member (Upper)	Undetermined	Ernestine Member (Lower)	Undetermined	Danzé (1956, p. 347)
<i>Corynepteris cupuliformis</i> Danzé	Non-marattialean ferns	Marie Member (Lower)	Undetermined	Marie Member (Upper)	Undetermined	Danzé (1956, p. 340)
<i>Corynepteris erosa</i> Gutbier	Non-marattialean ferns	Six-Sillons Member (Lower)	Béthune, pit N° 9, coal seam D	Edouard Member (Lower)	Lens, pit N° 5, Edouard	Danzé (1956, p. 345); Buisine (1961, p. 295)
<i>Corynepteris essinghii</i> (Andrae) Zeiller	Non-marattialean ferns	Modeste Member (Lower)	Anzin, pit Enclos, Tout Rond	Ernestine Member (Upper)	Drocourt, pit N° 2, coal seam undetermined	Danzé (1956, p. 323)
<i>Corynepteris magnifica</i> Gothan	Non-marattialean ferns	Ernestine Member (Middle)	Dourges, pit N° 2, St. Albert	NA	NA	Danzé (1956, pl. LXII); Bouroz (1969, p. 52)
cf. <i>Corynepteris magnifica</i> Gothan	Non-marattialean ferns	Ernestine Member (Upper)	Liévin, pit N° 1, Clémence	NA	NA	Danzé (1956, p. 337)
<i>Corynepteris tenuissima</i> Sternberg	Non-marattialean ferns	Pouilleuse Member (Lower)	Noeux, pit N° 8, coal seam N° 3	Pouilleuse Member (Upper)	NA	Danzé (1956, p. 350)
<i>Corynepteris</i> sp. Danzé	Non-marattialean ferns	Dusouch Member (Lower)	Courrières, pit N° 21, Désirée	NA	NA	Danzé (1956, p. 346); Bouroz (1969, p. 52)
<i>Crossotheca crepinii</i> Zeiller (= <i>Crossotheca boulayi</i> Zeiller - vide Brousmiche, 1982, 1983)	Non-marattialean ferns	Meunière Member (Upper)	Undetermined	Ernestine Member (Upper)	Liévin, pit N° 4, under Arago	Danzé (1956, p. 145); Laveine (1987, p. 89)
<i>Crossotheca schatzlarensis</i> (Stur) Kidston	Non-marattialean ferns	Meunière Member (Lower)	Aniche, pit St. René, coal seam undetermined	Ernestine Member (Lower)	Bruay, pit N° 5, coal seam N° 15	Danzé (1956, pp. 150–151); Loboziak (1971, p. 92–93)
<i>Desmopteris longifolia</i> (Presl) Stur	Marattialean ferns	Six-Sillons Member (Upper)	Lens, pit N° 16, borehole 16/24	Edouard Member (Lower)	Liévin, pit N° 2, Edouard	Buisine (1961, p. 295)
<i>Dicksonites potieri</i> Zeiller	Other pteridosperms	Ernestine Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Diplotmema leonardii</i> Bertrand	Lyginopteridales	Ernestine Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Discopteris occidentalis</i> Gothan (= <i>Discopteris bertrandii</i> Danzé - vide Brousmiche, 1977)	Non-marattialean ferns	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 21	Dusouch Member (Lower)	Liévin, pit N° 6, Désirée	Danzé (1956, p. 283); Bouroz (1969, p. 52)
<i>Discopteris opulenta</i> Danzé	Non-marattialean ferns	Meunière Member (Upper)	Undetermined	Dusouch Member (Lower)	Béthune, pit N° 4, Marie-Antoinette	Danzé (1956, p. 271); Laveine (1987, p. 89)
<i>Discopteris</i> cf. <i>schumanni</i> Stur	Non-marattialean ferns	Meunière Member (Middle)	Aniche, pit Notre-Dame, Déjardin	NA	NA	Danzé (1956, p. 275); Bouroz (1969, p. 52)
<i>Equisetites bretonii</i> Zeiller	Equisetales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Eremopteris artemisiafolioides</i> Schimper	Other pteridosperms	Ernestine Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Eremopteris zamioides</i> (Bertrand) Kidston	Other pteridosperms	Edouard Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Eusphenopteris</i> aff. <i>obtusiloba</i> (Brongniart) Novik	Lyginopteridales	Meunière Member (Lower)	Douai, pit Notre-Dame, Minangoye	NA	NA	Bertrand (1914, p. 224)
<i>Eusphenopteris broussieri</i> (Bertrand) van Amerom	Lyginopteridales	Modeste Member (Lower)	Aniche, Pit Archevêque, Gabrielle	Modeste Member (Upper)	Aniche, pit St. René, Modeste	Bertrand (1914, pp. 219, 222)
<i>Eusphenopteris hollandica</i> (Gothan and Jongmans) Novik	Lyginopteridales	St. Georges Member (Upper)	Undetermined	Olympe Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Eusphenopteris neuropteroides</i> (Boulay) Novik	Lyginopteridales	Olympe Member (Upper)	Undetermined	Edouard Member (Middle)	Undetermined	Laveine (1987, p. 89)
<i>Eusphenopteris nummularia</i> (Gutbier) Simson-Scharold	Lyginopteridales	Olympe Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Eusphenopteris striata</i> (Gothan) Novik	Lyginopteridales	Meunière Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Eusphenopteris trigonophylla</i> (Behrend) van Amerom (= <i>Sphenopteris laurentii</i> Andrae - vide van Amerom, 1975)	Lyginopteridales	Modeste Member (Lower)	Lens, pit N° 2, coal seam undetermined	Pouilleuse Member (Lower)	Noeux, pit N° 8, coal seam N° 3	Danzé (1956, p. 443)
<i>Fortopteris latifolia</i> (Zeiller) Boersma	Lyginopteridales	Pouilleuse Member (Upper)	Lens, pit N° 13, under RiMbrert	Dusouich Member (Upper)	Noeux, pit N° 2, bowette Sud	Danzé-Corsin (1953, pp. 238–239)
<i>Hymenophyllites quadridactylites</i>	Non-marattialean ferns	Modeste Member (Lower)	Liévin, pit N° 10, coal seam undetermined	Dusouich Member (Upper)	Bully-Grenay, pit N° 5, Ste. Barbe	Danzé (1956, p. 361)
<i>Karinopteris acuta</i> (Brongniart) Boersma (= <i>Mariopteris beneckeii</i> Huth <i>sensu</i> Kidston)	Lyginopteridales	Marie Member (Lower)	Undetermined	Meunière Member (Upper)	Carvin, pit N° 3, Petite veine	Danzé-Corsin (1953, p. 106); Corsin and Corsin (1970, p. 243)
<i>Karinopteris daviesii</i> (Kidston) Boersma	Lyginopteridales	Chandeleur Member (Lower)	Douai, pit Bonnel-Déjardin, coal seam N° 12	Pouilleuse Member (Lower)	Undetermined	Danzé-Corsin (1953, p. 112); Corsin and Corsin (1970, p. 243)
<i>Karinopteris dersoncourtii</i> (Zeiller) Boersma	Lyginopteridales	Olympe Member (Upper)	Douai, pit Notre-Dame, Olympe	Chandeleur Member (Upper)	Ostricourt, pit N° 14, Beyle	Bertrand (1914, p. 215); Danzé-Corsin (1953, pp. 96–97)
<i>Karinopteris</i> cf. <i>dersoncourtii</i> (Zeiller) Boersma	Lyginopteridales	Modeste Member (Lower)	Douchy, pit Schneider, Sophie	NA	NA	Danzé-Corsin (1953, p. 100)
<i>Karinopteris jacquotii</i> (Zeiller) Boersma	Lyginopteridales	Meunière Member (Middle)	Aniche, pit Notre-Dame, Layens	Six-Sillons Member (Upper)	Anzin, pit Cuvinot, coal seam undetermined	Danzé-Corsin (1953, p. 221)
<i>Karinopteris nobilis</i> (Achebohl ex Kidston) Boersma (= <i>Mariopteris hirsuta</i> Corsin - vide Cleal, 2008a)	Lyginopteridales	Meunière Member (Lower)	Ostricourt, pit N° 12, coal seam undetermined	Ernestine Member (Upper)	Liévin, pit N° 7, under Arago	Danzé-Corsin (1953, pp. 145, 227)
<i>Karinopteris soubeiranii</i> (Zeiller) Boersma	Lyginopteridales	Meunière Member (Lower)	Lens, pit N° 1, coal seam N° 11	Dusouich Member (Lower)	Liévin, pit N° 1, Arago	Danzé-Corsin (1953, p. 215); Loboziak (1971, p. 92–93)
<i>Laveineopteris dussartii</i> (Laveine) Laveine	Medullosales	Edouard Member (Upper)	Bruay, pit N° 3, coal seam M	NA	NA	Laveine (1967, p. 193)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Laveineopteris hollandica</i> (Stockmans) Cleal and Shute	Medullosales	Chandeleur Member (Lower)	Douai, Midi, Sale	Pouilleuse Member (Middle)	Douai, pit Dechy, coal seam N° 3	Laveine (1967, p. 160)
<i>Laveineopteris cf. hollandica</i> (Stockmans) Cleal and Shute	Medullosales	Meunière Member (Lower)	Valenciennes, pit Cuvinot, Levant	Meunière Member (Upper)	Lens, Vendin, coal seam undetermined	Laveine (1967, p. 162)
<i>Laveineopteris jongmansii</i> (Crookall) Cleal and Shute	Medullosales	Six-Sillons Member (Middle)	Lens, pit N° 16, coal seam undetermined	Six-Sillons Member (Upper)	Valenciennes, pit Cuvinot, coal seam N° 16	Laveine (1967, p. 181)
<i>Laveineopteris loshii</i> (Brongniart) Cleal et al.	Medullosales	Olympe Member (Upper)	Valenciennes, pit Sabatier, coal seam undetermined	Six-Sillons Member (Lower)	Béthune, Mazingarbe, coal seam undetermined	Laveine (1967, pp. 150–151)
<i>Laveineopteris morinii</i> (Bertrand ex Laveine) Cleal and Shute	Medullosales	Ernestine Member (Lower)	Noeux, pit N° 4, St. Victor	Dusouich Member (Lower)	Liévin, pit N° 4, Arago	Laveine (1967, pls. LXIV–LXV)
<i>Laveineopteris rarineris</i> (Bunbury) Cleal et al.	Medullosales	Six-Sillons Member (Middle)	Béthune, coal seam undetermined	Edouard Member (Upper)	Undetermined	Laveine (1967, p. 189; 1987, p. 89)
<i>Laveineopteris tenuifolia</i> (Sternberg) Cleal et al.	Medullosales	Chandeleur Member (Upper)	Bruay, pit N° 5, coal seam undetermined	Edouard Member (Lower)	Undetermined	Laveine (1967, p. 172; 1987, p. 89)
<i>Lepidodendron aculeatum</i> Sternberg	Lycopsids	Stérile Member (Upper)	Undetermined	Dusouich Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Lepidodendron dichotomum</i> Sternberg	Lycopsids	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Lepidodendron jaraczewskii</i> Zeiller	Lycopsids	Ernestine Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Lepidodendron lycopodioides</i> Sternberg	Lycopsids	Chandeleur Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Lepidodendron obovatum</i> Sternberg	Lycopsids	Modeste Member (Lower)	Douai, pit Bernicourt, Marcel	Meunière Member (Middle)	Douai, pit Notre-Dame, coal seam N° 2	Bertrand (1914, pp. 216, 225)
<i>Lepidodendron ophiurus</i> Brongniart	Lycopsids	Chandeleur Member (Upper)	Undetermined	Pouilleuse Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Lepidodendron rimosum</i> Sternberg	Lycopsids	Chandeleur Member (Upper)	Undetermined	Pouilleuse Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Lepidodendron simile</i> Kidston	Lycopsids	Olympe Member (Lower)	Douai, pit Sessevalle, Réserve	Modeste Member (Middle)	Douai, pit N° 5 of Escarpelle, Cécile	Bertrand (1914, pp. 217, 231); Bouroz (1969, p. 52)
<i>Lepidodendron veltheimii</i> Sternberg	Lycopsids	Stérile Member (Lower)	Undetermined	Stérile Member (Upper)	Undetermined	Corsin (1962, p. 1); Corsin and Corsin (1970, p. 241)
<i>Lepidodendron wortheni</i> Lesquereux	Lycopsids	Chandeleur Member (Upper)	Undetermined	Ernestine Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, p. 244)
<i>Lepidophloios acerosus</i> Lindley and Hutton	Lycopsids	Modeste Member (Upper)	Douai, pit St. René, Modeste	NA	NA	Bertrand (1914, p. 219); Bouroz (1969, p. 52)
<i>Lepidophloios laricinus</i> Sternberg	Lycopsids	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 690); Corsin and Corsin (1970, pp. 231–232)
<i>Linopteri obliqua</i> (Bunbury) Zeiller	Medullosales	Ernestine Member (Upper)	Bruay, pit N° 6, coal seam N° 8	Edouard Member (Middle)	Hénin, pit N° 9, Marthe	Laveine (1967, p. 293; 1987, p. 89)
<i>Linopteris neuropteroides</i> (Gutbier) Potonié	Medullosales	Modeste Member (Upper)	Douai, pit Archevêque, Noëlie	Dusouich Member (Lower)	Béthune, pit N° 2, St. Jean-Baptiste	Laveine (1967, p. 283; 1987, p. 89)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				Taxon
		FAD	Fossil site	LAD	Fossil site	
<i>Linopteris regniezii</i> Laveine	Medullosales	Six-Sillons Member (Middle)	Noeux, pit N° 2, St. Augustin	Six-Sillons Member (Upper)	Valenciennes, pit Cuvinot, coal seam N° 16	Laveine (1967, p. 296; 1987, p. 89)
<i>Linopteris subbrongniartii</i> Grand'Eury	Medullosales	Six-Sillons Member (Upper)	Valenciennes, pit Cuvinot, coal seam N° 18	Edouard Member (Upper)	Undetermined	Laveine (1967, p. 291; 1987, p. 89)
<i>Lobatopteris lobulata</i> (DalINVAL) Cleal	Marattialean ferns	Chandeleur Member (Lower)	Bruay, pit N° 2, Célestine	Edouard Member (Middle)	Courrières, pit N° 21, Marthe	DalINVAL (1960, pp. 171–172)
<i>Lobatopteris cf. lobulata</i> (DalINVAL) Cleal	Marattialean ferns	Ernestine Member (Middle)	Liévin, pit N° 3, Omérine	NA	NA	DalINVAL (1960, p. 175)
<i>Lobatopteris miltonii</i> (Artis) Wagner	Marattialean ferns	Modeste Member (Lower)	Valenciennes, pit Agache, coal seam N° 2	Dusouich Member (Middle)	Liévin, pit N° 4, Léonard	DalINVAL (1960, pp. 145–149); Loboziak (1971, p. 92–93)
<i>Lonchopteris briceii</i> Brongniart	Medullosales	Modeste Member (Middle)	Douai, pit N° 5 of Escarpelle, Cécile	Pouilleuse Member (Lower)	Douai, pit Notre-Dame, coal seam N° 7	Bertrand (1914, pp. 217, 226); Bouroz (1969, p. 52)
<i>Lonchopteris eschweiliana</i> Andrae	Medullosales	Modeste Member (Middle)	Douai, pit Notre-Dame, Cécile	Meunière Member (Moyen)	Valenciennes, pit Thiers, coal seam N° 3	Buisine (1961, p. 242); Bouroz (1969, p. 52)
<i>Lonchopteris legrandii</i> Bouroz	Medullosales	Pouilleuse Member (Upper)	Lens, pit N° 18, coal seam undetermined	Ernestine Member (Upper)	Béthune, coal seam undetermined	Buisine (1961, pp. 257–258)
<i>Lonchopteris monomakhoffii</i> Buisine	Medullosales	Six-Sillons Member (Upper)	Bruay, pit N° 6, coal seam undetermined	Ernestine Member (Lower)	Douai, pit N° 8, Josepha	Buisine (1961, p. 247)
<i>Lonchopteris petitii</i> Buisine	Medullosales	Chandeleur Member (Lower)	Dourges, pit N° 4, Nouvelle veine	Six-Sillons Member (Middle)	Undetermined	Buisine (1961, pp. 252–253)
<i>Lonchopteris rugosa</i> Brongniart	Medullosales	Modeste Member (Lower)	Undetermined	Six-Sillons Member (Lower)	Marles, pit N° 6, coal seam undetermined	Buisine (1961, pp. 225, 230)
<i>Macroneuropteris scheuchzeri</i> (Hoffmann) Cleal et al.	Medullosales	Pouilleuse Member (Lower)	Lens, pit N° 2, coal seam undetermined	Edouard Member (Upper)	Bruay, pit N° 6, coal seam M	Laveine (1967, pp. 246–247)
<i>Mariopteris bourozi</i> Danzé-Corsin	Lyginopteridales	Pouilleuse Member (Lower)	Bruay, pit N° 5, coal seam N° 39	NA	NA	Danzé-Corsin (1953, p. 117); Loboziak (1971, p. 92–93)
<i>Mariopteris carnosa</i> Corsin (= <i>Mariopteris nervosa</i> Brongniart; = <i>Mariopteris opulenta</i> Danzé-Corsin - vide Cleal, 2008a)	Lyginopteridales	Meunière Member (Upper)	Douai, pit N° 8, coal seam undetermined	Edouard Member (Upper)	Béthune, pit N° 6, Girard	Danzé-Corsin (1953, p. 161); Laveine (1987, p. 89)
<i>Mariopteris hirta</i> Stur	Lyginopteridales	Chandeleur Member (Lower)	Lens, pit N° 3, Meurchin	Six-Sillons Member (Lower)	Bruay, pit N° 5, coal seam N° 32	Danzé-Corsin (1953, p. 151); Loboziak (1971, p. 92–93)
<i>Mariopteris cf. hirta</i> Stur	Lyginopteridales	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 21	NA	NA	Danzé-Corsin (1953, p. 153); Loboziak (1971, p. 92–93)
<i>Mariopteris laciniata</i> Potonié	Lyginopteridales	Stérile Member (Lower)	Undetermined	Stérile Member (Lower)	Undetermined	Corsin (1962, p. 1); Corsin and Corsin (1970, p. 241)
<i>Mariopteris lobatifolia</i> Kidston	Lyginopteridales	Modeste Member (Lower)	Douai, pit Dechy, Hélène	Dusouich Member (Upper)	Lens, pit undetermined, Saint-Louis	Danzé-Corsin (1953, p. 208)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Mariopteris microsauveurii</i> Danzé-Corsin	Lyginopteridales	Pouilleuse Member (Upper)	Aniche, pit Dechy, Eloi	NA	NA	Danzé-Corsin (1953, p. 199)
<i>Mariopteris mosana</i> Willière	Lyginopteridales	St. Georges Member (Lower)	Undetermined	Marie Member (Upper)	Undetermined	Corsin (1962, p. 2); Corsin and Corsin (1970, p. 243)
<i>Mariopteris muricata</i> (Brongniart) Zeiller	Lyginopteridales	Modeste Member (Lower)	Aniche, pit Notre-Dame, Hélène	Ernestine Member (Upper)	Douai, pit N° 4, Elisabeth	Danzé-Corsin (1953, pp. 132, 134)
<i>Mariopteris nervosauveurii</i> Danzé-Corsin	Lyginopteridales	Ernestine Member (Lower)	Béthune, pit N° 3, St. Victor	Ernestine Member (Middle)	Dourges, pit N° 4, Ste Croix	Danzé-Corsin (1953, pp. 166–167)
<i>Mariopteris odontophylla</i> Danzé-Corsin	Lyginopteridales	Modeste Member (Lower)	Aniche, pit Gayant, Marcel	NA	NA	Danzé-Corsin (1953, p. 139)
<i>Mariopteris pachyphylla</i> Danzé-Corsin	Lyginopteridales	Meunière Member (Upper)	Carvin, pit N° 3, coeal seam N° 3	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 21	Danzé-Corsin (1953, p. 203); Loboziak (1971, p. 92–93)
<i>Mariopteris robusta</i> Kidston	Lyginopteridales	Six-Sillons Member (Upper)	Anzin, pit Cuvinot, coal seam N° 19	Dusouich Member (Upper)	Bruay, pit N° , Ste Aline	Danzé-Corsin (1953, p. 180); Loboziak (1971, p. 92–93)
<i>Mariopteris roussinii</i> Bertrand	Lyginopteridales	Pouilleuse Member (Upper)	Aniche, pit Dechy, coal seam N° 3	NA	NA	Danzé-Corsin (1953, p. 248)
<i>Mariopteris sauveurii</i> (Brongniart) Stur	Lyginopteridales	Meunière Member (Middle)	Douai, pit Notre-Dame, coal seam N° 2	Dusouich Member (Upper)	Courrières, pit N° 4, Augustine	Danzé-Corsin (1953, p. 191); Loboziak (1971, p. 92–93)
<i>Myriotheca desaillyi</i> Zeiller	Non-marattialean ferns	Six-Sillons Member (Lower)	Valenciennes, pit Crespain, coal seam undetermined	Ernestine Member (Upper)	Drocourt, pit N° 4, coeal seam undetermined	Danzé (1956, p. 167)
<i>Myriotheca monomakhoffi</i> Danzé	Non-marattialean ferns	Six-Sillons Member (Lower)	Douai, pit N° 8, coal seam undetermined	Ernestine Member (Upper)	Liévin, pit N° 4, Arago	Danzé (1956, p. 171)
<i>Neuralethopteris jongmansii</i> Laveine	Medullosales	Stérile Member (Upper)	Valenciennes, pit Heurteau, coal seam undetermined	Modeste Member (Lower)	Douai, pit Archevêque, Gabrielle	Laveine (1967, p. 112)
<i>Neuralethopteris larischii</i> (Susta) Laveine	Medullosales	Stérile Member (Middle)	Undetermined	Marie Member (Upper)	Valenciennes, pit Sabatier, coal seam undetermined	Laveine (1967, p. 106)
<i>Neuralethopteris rectinervis</i> (Kidston) Laveine	Medullosales	Modeste Member (Middle)	Escarpelle, pit N° 9, coal seam undetermined	NA	NA	Laveine (1967, p. 124)
<i>Neuralethopteris</i> cf. <i>rectinervis</i> (Kidston) Laveine	Medullosales	Modeste Member (Upper)	Undetermined	NA	NA	Laveine (1967, p. 126)
<i>Neuralethopteris schlehanii</i> (Stur) Cremer	Medullosales	Olympe Member (Middle)	Escarpelle, pit N° 9, coal seam undetermined	Chandeleur Member (Upper)	Bruay, pit N° 2, Césarine	Laveine (1967, p. 119)
<i>Neuralethopteris</i> sp. Laveine	Medullosales	Modeste Member (Upper)	Valenciennes, pit St. Mark, coal seam undetermined	NA	NA	Laveine (1967, p. 129)
<i>Neuropteris bourozii</i> Laveine	Medullosales	Chandeleur Member (Middle)	Valenciennes, pit La Grange, Anita	Meunière Member (Middle)	Oignies, pit N° 6, Terreuse	Laveine (1967, p. 156)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Neuropteris cf. bourozzii</i> Laveine	Medullosales	Meunière Member (Lower)	Douai, pit Dechy, coal seam undetermined	Pouilleuse Member (Lower)	Undetermined	Laveine (1967, p. 163)
<i>Neuropteris duprei</i> Laveine	Medullosales	Chandeleur Member (Lower)	Bruay, pit N° 2, coal seam undetermined	Pouilleuse Member (Lower)	Lens, Pit N° 12, coal seam undetermined	Laveine (1967, p. 166)
<i>Neuropteris ghayei</i> Willièrè	Medullosales	Olympe Member (Middle)	Douai, pit Archevèque, Petite veine	Chandeleur Member (Upper)	Douai, pit Lemay, coal seam undetermined	Laveine (1967, pp. 196–197)
<i>Neuropteris heterophylla</i> (Brongniart) Sternberg	Medullosales	Chandeleur Member (Lower)	Bruay, pit N° 5, coal seam undetermined	Six-Sillons Member (Lower)	Courrières, pit N° 5, coal seam undetermined	Laveine (1967, p. 144)
<i>Neuropteris obliqua</i> (= <i>Neuropteris semireticulata</i> ; = <i>Reticulopteris muensteri</i> (Eichwald) Gothan - vide Thomas et al., 2020)	Medullosales	Olympe Member (Upper)	Auchel, pit N° 5, coal seam undetermined	Edouard Member (Upper)	Bruay, pit N° 6, coal seam M	Laveine (1967, pp. 204, 223)
<i>Neuropteris ovata</i> Hoffmann	Medullosales	Dusouch Member (Lower)	Hénin, pit N° 9, coal seam undetermined	Edouard Member (Middle)	Courrières, pit N° 21, Marthe	Laveine (1967, p. 237)
<i>Neuropteris parvifolia</i> Stockmans	Medullosales	Pouilleuse Member (Upper)	Noeux, pit N° 3, St. Charles	Ernestine Member (Lower)	Hénin, pit N° 5, coal seam undetermined	Laveine (1967, pp. 210–211)
<i>Neuropteris willieri</i> Laveine	Medullosales	Chandeleur Member (Middle)	Undetermined	Meunière Member (Lower)	Ligny, pit N° 2, coal seam undetermined	Laveine (1967, pl. LXII)
<i>Oligocarpia brongniartii</i> Stur	Non-marattialean ferns	Meunière Member (Upper)	Douai, pit St. René, coal seam undetermined	Dusouch Member (Upper)	Bully-Grenay, pit N° 5, St. Alexis	Danzé (1956, p. 299)
<i>Palmatopteris furcata</i> (Brongniart) Potonié	Lyginopteridales	Modeste Member (Lower)	Undetermined	Modeste Member (Upper)	Undetermined	Corsin (1962, p. 2); Corsin and Corsin (1970, p. 243)
<i>Palmatopteris spinosa</i> (Goeppert) Potonié	Lyginopteridales	Meunière Member (Lower)	Douai, pit Notre-Dame, Minangoye	NA	NA	Bertrand (1914, p. 224)
<i>Paripteris gigantea</i> (Sternberg) Gothan	Medullosales	Marie Member (Middle)	Undetermined	Pouilleuse Member (Lower)	Douai, pit Dechy, coal seam N° 2	Laveine (1967, pp. 258–259)
<i>Paripteris linguaeifolia</i> (Bertrand) Laveine	Medullosales	Meunière Member (Lower)	Valenciennes, pit Ledoux, coal seam undetermined	Ernestine Member (Middle)	Bruay, pit N° 6, coal seam N° 9	Laveine (1967, pp. 270–271)
<i>Paripteris pseudogigantea</i> (Potonié) Gothan	Medullosales	Chandeleur Member (Upper)	Douai, pit Barrois, coal seam undetermined	Ernestine Member (Upper)	Hénin, pit N° 9, coal seam undetermined	Laveine (1967, pp. 264–265)
<i>Pecopteridium leratii</i> Buisine	Medullosales	Ernestine Member (Lower)	Drocourt, pit N° 4, coal seam undetermined	Ernestine Member (Upper)	Courrières, pit N° 21, Brillante	Buisine (1961, p. 272)
<i>Pecopteridium vermelenii</i> Buisine	Medullosales	Ernestine Member (Lower)	Liévin, pit N° 5, coal seam undetermined	Ernestine Member (Middle)	Liévin, pit N° 5, Omérine	Buisine (1961, p. 277)
<i>Pecopteris aspera</i> Brongniart	Non-marattialean ferns	Stérile Member (Upper)	Undetermined	Modeste Member (Lower)	Douai, pit Lemay, coal seam undetermined	Danzé (1956, p. 47); Corsin and Corsin (1970, p. 241)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Pecopteris avoldensis</i> (Stur) DalINVAL	Non-marattialean ferns	Modeste Member (Lower)	Undetermined	Edouard Member (Lower)	Liévin, pit N° 1, Edouard	DalINVAL (1960, pp. 193–194); Laveine (1987, p. 89)
<i>Pecopteris bourozii</i> DalINVAL	Marattialean ferns	Meunière Member (Lower)	Lens, pit N° 18, coal seam N° 12	Ernestine Member (Lower)	Douai, pit N° 8, Hélène	DalINVAL (1960, p. 133)
<i>Pecopteris corsinii</i> Wagner	Marattialean ferns	Modeste Member (Lower)	Valenciennes, pit Enclos, middle coal seam	Dusouich Member (Middle)	Liévin, pit N° 7, Léonard	DalINVAL (1960, p. 164)
<i>Pecopteris</i> cf. <i>hemitelioides</i> Brongniart	Marattialean ferns	Dusouich Member (Lower)	Courrières, pit N° 21, Désirée	NA	NA	DalINVAL (1960, p. 177); Bouroz (1969, p. 52)
<i>Pecopteris hirsuta</i> DalINVAL	Marattialean ferns	Meunière Member (Upper)	Auchel, pit N° 9, undetermined	Dusouich Member (Middle)	Lens, pit N° 9, Dusouich	DalINVAL (1960, p. 153); Loboziak (1971, p. 92–93)
<i>Pecopteris</i> cf. <i>hirsuta</i> DalINVAL	Marattialean ferns	Modeste Member (Lower)	Douchy, pit Schneider, Sophie	Modeste Member (Upper)	Idem	DalINVAL (1960, p. 155)
<i>Pecopteris intermedia</i> Bertrand	Non-marattialean ferns	Chandeleur Member (Upper)	Aniche, pit Dechy, Chandeleur	Meunière Member (Upper)	Valenciennes, pit Cuvinot, coal seam undetermined	DalINVAL (1960, pp. 127–128)
<i>Pecopteris pennaeformis</i> Brongniart	Non-marattialean ferns	Modeste Member (Lower)	Lens, pit N° 4–3, coal seam undetermined	Six-Sillons Member (Upper)	Undetermined	DalINVAL (1960, p. 92); Laveine (1987, p. 89)
<i>Pecopteris plumosadentata</i> Corsin	Non-marattialean ferns	Modeste Member (Lower)	Douai, pit N° 9, coal seam undetermined	Edouard Member (Upper)	Undetermined	DalINVAL (1960, pp. 67, 78)
<i>Pecopteris</i> cf. <i>plumosadentata</i> Corsin	Non-marattialean ferns	Modeste Member (Lower)	Undetermined	Chandeleur Member (Upper)	Undetermined	DalINVAL (1960, pl. XV)
<i>Pecopteris precyatheae</i> (Schlotheim) Brongniart	Marattialean ferns	Dusouich Member (Upper)	Liévin, pit N° 4, Frédéric	NA	NA	DalINVAL (1960, p. 179)
<i>Pecopteris prepolyomorpha</i> (Brongniart) DalINVAL	Marattialean ferns	Dusouich Member (Middle)	Liévin, pit N° 3, Dusouich	NA	NA	DalINVAL (1960, p. 182); Loboziak (1971, p. 92–93)
<i>Pecopteris</i> cf. <i>saraefolia</i> Bertrand	Marattialean ferns	Dusouich Member (Middle)	Liévin, pit N° 3, Dusouich	NA	NA	DalINVAL (1960, p. 185); Loboziak (1971, p. 92–93)
<i>Pecopteris simonii</i> Zeiller (= <i>Palaeoweichselia defrancei</i> ) Brongniart - vide Laveine et al., (1978)	Medullosales	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Lower)	Undetermined	Laveine (1987, p. 89); Laveine and Goubet (1995, p. 33)
<i>Pecopteris</i> cf. <i>simonii</i> Zeiller	Medullosales	Pouilleuse Member (Lower)	Douai, pit N° 10, Simone	Ernestine Member (Upper)	Courrières, pit N° 9, coal seam undetermined	DalINVAL (1960, p. 207)
<i>Pecopteris stievenardi</i> DalINVAL	Non-marattialean ferns	Six-Sillons Member (Lower)	Douai, pit Notre-Dame, Claire	Edouard Member (Upper)	Undetermined	DalINVAL (1960, p. 200)
<i>Pecopteris vedrinei</i> DalINVAL (= <i>Margaritopteris conwayi</i> Lindley and Hutton - vide Laveine et al., (1977))	Medullosales	Olympe Member (Upper)	Valenciennes, pit Casimir, Denise	Pouilleuse Member (Middle)	Aniche, pit Dechy, Léon	Laveine et al. (1977, p. 785); Laveine and Goubet (1995, p. 33)



Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Pecopteris volkmannii</i> SauvEUR	Non-marattialealean ferns	Modeste Member (Upper)	Douai, pit Arenberg, coal seam undetermined	Ernestine Member (Middle)	Courrières, pit N° 7, coal seam undetermined	DalINVAL (1960, pp. 118, 121)
<i>Pecopteris</i> cf. <i>volkmannii</i> SauvEUR	Non-marattialealean ferns	Meunière Member (Upper)	Douai, pit Notre-Dame, coam seam N°2	NA	NA	DalINVAL (1960, p. 123)
<i>Pecopteris</i> sp. DalINVAL	Non-marattialealean ferns	Meunière Member (Middle)	Douai, pit St. René, Déjardin	NA	NA	DalINVAL (1960, p. 107); BouROZ (1969, p. 52)
<i>Pinakodendron ohmannii</i> Weiss	Lycopsids	Olympe Member (Upper)	Undetermined	Chandeleur Member (Upper)	Undetermined	LaveINE (1987, p. 89)
<i>Renaultia acutiloba</i> DalINVAL	Non-marattialealean ferns	Six-Sillons Member (Upper)	Béthune, pit N° 5, coal seam undetermined	Ernestine Member (Upper)	Bruay, pit N° 4, coal seam F	Danzé (1956, p. 226)
<i>Renaultia chaerophylloides</i> (Brongniart) ZeILLER	Non-marattialealean ferns	Meunière Member (Lower)	Undetermined	Dusouich Member (Middle)	Liévin, pit N° 3, Alfred	Danzé (1956, pp. 198–199); Loboziak (1971, p. 92–93)
<i>Renaultia crepinii</i> (Stur) Gothan	Non-marattialealean ferns	Meunière Member (Middle)	Douai, pit St. René, Déjardin	NA	NA	Danzé (1956, p. 210); BouROZ (1969, p. 52)
<i>Renaultia footeri</i> (Marrat) BrousmICHE	Non-marattialealean ferns	Modeste Member (Middle)	Aniche, pit Gayant, Cécile	Chandeleur Member (Lower)	Aniche, pit Vuillemin, Vieille Marie	Danzé (1956, p. 448); BouROZ (1969, p. 52)
<i>Renaultia</i> cf. <i>footeri</i> (Marrat) BrousmICHE	Non-marattialealean ferns	Ernestine Member (Lower)	Ferfay, pit N° 4, Ste Marie	Ernestine Member (Upper)	Liévin, pit N° 6, Delphine	Danzé (1956, p. 450)
<i>Renaultia gracilis</i> Brongniart	Non-marattialealean ferns	Modeste Member (Lower)	Undetermined	Dusouich Member (Upper)	Aniche, pit Déjardin, August	Danzé (1956, pp. 216, 221)
<i>Renaultia rotundifolia</i> AndRAE	Non-marattialealean ferns	Pouilleuse Member (Lower)	Aniche, pit Dechy, coal seam N° 2	Ernestine Member (Upper)	Béthune, pit N° 4, coal seam undetermined	Danzé (1956, p. 206)
<i>Renaultia schatzlarensis</i> Stur	Non-marattialealean ferns	Chandeleur Member (Lower)	Lens, pit N° 18, Désirée	Chandeleur Member (Upper)	Douai, pit Sessevalle, Ernest	Danzé (1956, p. 180); BouROZ (1969, p. 52)
<i>Renaultia schwerini</i> Stur	Non-marattialealean ferns	Modeste Member (Upper)	Aniche, pit St. René, Modeste	Ernestine Member (Upper)	Ferfay, pit N° 4, Sainte Marie	Danzé (1956, p. 193); BouROZ (1969, p. 52)
<i>Renaultia villosa</i> Crépin	Non-marattialealean ferns	Ernestine Member (Middle)	Liévin, pit N° 1, Omérine	Ernestine Member (Upper)	Liévin, pit N° 3, Céline	DalINVAL (1960, pp. 185–186)
<i>Reticulopteris</i> sp. LaveINE	Medullosales	Dusouich Member (Lower)	Liévin, pit N° 3, coal seam undetermined	NA	NA	LaveINE (1967, p. 224)
<i>Rhodea subpetiolata</i> (Potonié) ZeILLER	Non-marattialealean ferns	Modeste Member (Lower)	Aniche, Pit Archevéque, Gabrielle	NA	NA	Bertrand (1914, p. 222)
<i>Samaropsis fluitans</i> (Dawson) Weiss	Cordaitales	Pouilleuse Member (Upper)	Undetermined	Six-Sillons Member (Middle)	Undetermined	ZeILLER (1888, p. 692); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria acuta</i> ZeILLER	Lycopsids	Chandeleur Member (Upper)	Undetermined	Meunière Member (Middle)	Undetermined	ZeILLER (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria bretoni</i> (Bertrand) Corsin	Lycopsids	Marie Member (Lower)	Undetermined	Marie Member (Upper)	Undetermined	Corsin (1962, p. 2); Corsin and Corsin (1970, p. 243)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Sigillaria cordigera</i> Zeiller	Lycopsids	Meunière Member (Middle)	Undetermined	Pouilleuse Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria davreuxii</i> Brongniart	Lycopsids	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, p. 231–232)
<i>Sigillaria deutschii</i> Brongniart	Lycopsids	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria elegans</i> Sternberg (= <i>Sigillaria elegantula</i> Weiss - vide Crookall, 1966)	Lycopsids	St. Georges Member (Lower)	Undetermined	Chandeleur Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Sigillaria elongata</i> Brongniart	Lycopsids	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, p. 231–232)
<i>Sigillaria laevigata</i> Brongniart (= <i>Sigillaria ovata</i> Sauveur; = <i>Sigillaria reniformis</i> Brongniart - vide Crookall, 1966)	Lycopsids	Olympe Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, p. 231–232, 243)
<i>Sigillaria mamillaris</i> Brongniart (= <i>Sigillaria boblayi</i> Brongniart; = <i>Sigillaria poluploca</i> Boulay; = <i>Sigillaria scutellata</i> Brongniart; = <i>Sigillaria weissii</i> Zeiller - vide Crookall, 1966)	Lycopsids	Chandeleur Member (Lower)	Undetermined	Edouard Member (Lower)	Undetermined	Laveine (1987, p. 89)
<i>Sigillaria micaudii</i> Zeiller	Lycopsids	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria nudicaulis</i> Boulay	Lycopsids	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria principis</i> Weiss	Lycopsids	Meunière Member (Middle)	Undetermined	Ernestine Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232, 244)
<i>Sigillaria reticulata</i> Lesquereux	Lycopsids	Meunière Member (Middle)	Undetermined	Pouilleuse Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria rugosa</i> Brongniart	Lycopsids	Marie Member (Upper)	Undetermined	Pouilleuse Member (Lower)	Undetermined	Laveine (1987, p. 89)
<i>Sigillaria sauveurii</i> Zeiller	Lycopsids	Chandeleur Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria tessellata</i> Brongniart	Lycopsids	Chandeleur Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria transversalis</i> Brongniart	Lycopsids	Pouilleuse Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Sigillaria walchii</i> Sauveur	Lycopsids	Meunière Member (Lower)	Douai, pit Notre-Dame, Minangoye	Pouilleuse Member (Lower)	Douai, pit Notre-Dame, coal seam N° 7	Bertrand (1914, pp. 224, 226)
<i>Sphenophyllum cuneifolium</i> Stur	Sphenophyllales	Marie Member (Upper)	Undetermined	Six-Sillons Member (Middle)	Undetermined	Laveine (1987, p. 89)
<i>Sphenophyllum emarginatum</i> Brongniart	Sphenophyllales	Pouilleuse Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Sphenophyllum majus</i> (Bronn) Bronn	Sphenophyllales	Pouilleuse Member (Middle)	Undetermined	Edouard Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Sphenophyllum myriophyllum</i> Crépin	Sphenophyllales	Olympe Member (Upper)	Undetermined	Six-Sillons Member (Lower)	Undetermined	Laveine (1987, p. 89)
<i>Sphenophyllum tenerrinum</i> Ettinghausen	Sphenophyllales	Stérile Member (Upper)	Undetermined	Marie Member (Upper)	Undetermined	Laveine (1987, p. 89)
<i>Sphenopteris andraeana</i> von Roehl	Lyginopteridales	Meunière Member (Lower)	Anzin, pit Roelux, coal seam undetermined	Six-Sillons Member (Lower)	Anzin, pit Crespin, level 745	Danzé-Corsin (1953, p. 243)
<i>Sphenopteris</i> cf. <i>arberi</i> Kidston	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 491)
<i>Sphenopteris</i> cf. <i>aschenborni</i> Stur	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 421)
<i>Sphenopteris aureli</i> Danzé	Non-marattialean ferns	Meunière Member (Upper)	Anzin, pit Thiers, Boulangère	Dusouich Member (Middle)	Liévin, pit N° 3, Alfred	Danzé (1956, pp. 393–397); Loboziak (1971, p. 92–93); Laveine et al. (1977, p. 785)
<i>Sphenopteris</i> cf. <i>cantiana</i> Kidston	Non-marattialean ferns	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 18	NA	NA	Danzé (1956, p. 411); Loboziak (1971, p. 92–93)
<i>Sphenopteris corifolia</i> Kidston	Non-marattialean ferns	Six-Sillons Member (Lower)	Noeaux, pit N° 2, Espérance	Ernestine Member (Upper)	Bruay, pit N° 3, coal seam N° 8	Danzé (1956, pp. 512–513); Loboziak (1971, p. 92–93)
<i>Sphenopteris delavallii</i> Zeiller	Non-marattialean ferns	Modeste Member (Middle)	Aniche, pit undetermined, Cécile	NA	NA	Danzé (1956, p. 508); Bouroz (1969, p. 52)
<i>Sphenopteris</i> cf. <i>delavallii</i> Zeiller	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 509)
<i>Sphenopteris dentaefolia</i> Danzé	Non-marattialean ferns	Meunière Member (Lower)	Auchel, pit N° 3, coal seam undetermined	Dusouich Member (Lower)	Lens, pit N° 2, coal seam undetermined	Danzé (1956, p. 473)
<i>Sphenopteris</i> cf. <i>devians</i> Gothan	Non-marattialean ferns	Meunière Member (Lower)	Undetermined	NA	NA	Danzé (1956, p. 389)
<i>Sphenopteris dissymetrica</i> Danzé	Non-marattialean ferns	Ernestine Member (Upper)	Lens, pit N° 1, Cécile	NA	NA	Danzé (1956, p. 408); Dalinval (1960, p. 194)
<i>Sphenopteris dixonii</i> Kidston	Non-marattialean ferns	Dusouich Member (Lower)	Liévin, pit N° 3, Arago	NA	NA	Danzé (1956, p. 476)
<i>Sphenopteris douvillei</i> Zeiller	Non-marattialean ferns	Six-Sillons Member (Lower)	Béthune, pit N° 4, coal seam undetermined	Dusouich Member (Middle)	Lens, pit N° 9, Dusouich	Danzé (1956, pp. 488–489); Loboziak (1971, p. 92–93)
<i>Sphenopteris dufayi</i> Danzé	Non-marattialean ferns	Olympe Member (Lower)	Undetermined	Olympe Member (Upper)	Undetermined	Danzé (1956, p. 418)
<i>Sphenopteris formosa</i> Gutbier	Non-marattialean ferns	Modeste Member (Middle)	Aniche, pit Gayant, Cécile	NA	NA	Danzé (1956, p. 529); Bouroz (1969, p. 52)
<i>Sphenopteris</i> cf. <i>fragilis</i> Schlotheim	Non-marattialean ferns	Chandeleur Member (Lower)	Aniche, pit Vuillemin, Vieille Marie	NA	NA	Bertrand (1914, p. 219); Danzé (1956, p. 448)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Sphenopteris hansae</i> Gothan	Non-marattialean ferns	Modeste Member (Middle)	Aniche, pit Gayant, Cécile	NA	NA	Danzé (1956, p. 425); Bouroz (1969, p. 52)
<i>Sphenopteris kayi</i> Arber	Non-marattialean ferns	Ernestine Member (Upper)	Dourges, pit N° 2, St. Alfred	NA	NA	Danzé (1956, p. 495)
<i>Sphenopteris kilimli</i> Kidston	Non-marattialean ferns	Dusouich Member (Lower)	Béthune, pit N° 4, Marie-Antoinette	NA	NA	Danzé (1956, p. 504)
<i>Sphenopteris latinervis</i> Danzé	Non-marattialean ferns	Pouilleuse Member (Lower)	Aniche, pit Notre-Dame, coal seam N° 5	Ernestine Member (Upper)	Liévin, pit N° 3, Céline	Danzé (1956, pp. 414–415)
<i>Sphenopteris microcyclos</i> Gothan	Non-marattialean ferns	Six-Sillons Member (Lower)	Béthune, pit N° 9, coal seam D	Dusouich Member (Middle)	Lens, pit undetermined, Dusouich	Danzé (1956, p. 345, 458); Loboziak (1971, p. 92–93)
<i>Sphenopteris microscopica</i> Crépin	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 465)
<i>Sphenopteris mixta</i> (Schimper) Zeiller	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Danzé (1956, p. 435)
<i>Sphenopteris cf. mixta</i> (Schimper) Zeiller	Non-marattialean ferns	Ernestine Member (Upper)	Courrières, pit N° 7, St. Nicolas	NA	NA	Danzé (1956, p. 437); Bouroz (1969, p. 52)
<i>Sphenopteris obtusedentata</i> Gothan	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Ernestine Member (Middle)	Liévin, pit N° 15, Omérine	Danzé (1956, pp. 453–454)
<i>Sphenopteris parviloba</i> Danzé	Non-marattialean ferns	Dusouich Member (Middle)	Lens, pit undetermined, Dusouich	NA	NA	Danzé (1956, p. 516)
<i>Sphenopteris pecopteroides</i> Kidston	Non-marattialean ferns	Pouilleuse Member (Lower)	Douai, pit Notre-Dame, coal seam undetermined	Ernestine Member (Upper)	Dourges, pit N° 7, Elisabeth	Danzé (1956, p. 521)
<i>Sphenopteris cf. pecopteroides</i> Kidston	Non-marattialean ferns	Ernestine Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Danzé (1956, p. 523)
<i>Sphenopteris pseudomarrati</i> Danzé	Non-marattialean ferns	Ernestine Member (Middle)	Béthune, pit N° 2, coal seam undetermined	NA	NA	Danzé (1956, p. 461); Loboziak (1971, p. 92–93)
<i>Sphenopteris pulcherrima</i> Crépin	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 469)
<i>Sphenopteris rotundiloba</i> Danzé	Non-marattialean ferns	Six-Sillons Member (Upper)	Drocourt, pit N° 4, coal seam undetermined	Ernestine Member (Upper)	Béthune, pit N° 4, coal seam undetermined	Danzé (1956, p. 430); Loboziak (1971, p. 92–93)
<i>Sphenopteris rutaeifolia</i> Gutbier (= <i>Sphenopteris stipulata</i> Gutbier - vide Brousmiche, 1983)	Non-marattialean ferns	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 18	Dusouich Member (Middle)	Liévin, pit N° 1, Dusouich	Danzé (1956, pp. 401, 405); Loboziak (1971, p. 92–93)
<i>Sphenopteris cf. selbyensis</i> Kidston	Non-marattialean ferns	Chandeleur Member (Lower)	Anzin, pit Ledoux, 9 Paumes	Pouilleuse Member (Upper)	Aniche, pit Dechy, Eloi	Danzé (1956, p. 480)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Sphenopteris seawardii</i> Kidston	Non-marattialean ferns	Ernestine Member (Lower)	Escarpelle, pit N° 7, coal seam undetermined	Ernestine Member (Upper)	Béthune, pit N° 2, coal seam undetermined	Danzé (1956, p. 500); Loboziak (1971, p. 92–93)
<i>Sphenopteris souichii</i> Zeiller	Non-marattialean ferns	Chandeleur Member (Middle)	Undetermined	Six-Sillons Member (Upper)	Bruay, pit N° 14, coal seam N° 17	Danzé (1956, p. 383); Loboziak (1971, p. 92–93)
<i>Sphenopteris villeti</i> Bertrand	Non-marattialean ferns	Ernestine Member (Lower)	Undetermined	Ernestine Member (Upper)	Undetermined	Danzé (1956, p. 537)
<i>Sphenopteris cf. villeti</i> Bertrand	Non-marattialean ferns	Six-Sillons Member (Lower)	Undetermined	Six-Sillons Member (Upper)	Undetermined	Danzé (1956, p. 539)
<i>Sphenopteris woodwardi</i> Kidston	Non-marattialean ferns	Modeste Member (Lower)	Undetermined	Chandeleur Member (Upper)	Undetermined	Danzé (1956, p. 533)
<i>Sphenopteris</i> sp. Danzé	Non-marattialean ferns	Modeste Member (Lower)	Undetermined	Modeste Member (Upper)	Undetermined	Danzé (1956, p. 426)
<i>Sphyropteris frankiana</i> Gothan	Non-marattialean ferns	Chandeleur Member (Upper)	Undetermined	NA	NA	Danzé (1956, p. 263)
<i>Stellatheca latiloba</i> Danzé	Non-marattialean ferns	Six-Sillons Member (Upper)	Bruay, pit N° 5, coal seam N° 21	NA	NA	Danzé (1956, p. 287); Loboziak (1971, p. 92–93)
<i>Sturia amoena</i> (Stur) Němejc	Non-marattialean ferns	Ernestine Member (Lower)	Ferfay, pit N° 4, Ste Marie	Ernestine Member (Upper)	Liévin, pit N° 3, Céline	Danzé (1956, p. 376)
<i>Taeniopteris zeilleri</i> Bertrand	Medullosales	Edouard Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Ulodendron haidingeri</i> Ettingshausen	Lycopsids	Ernestine Member (Lower)	Undetermined	Edouard Member (Upper)	Undetermined	Corsin (1962, p. 5); Corsin and Corsin (1970, p. 244)
<i>Ulodendron majus</i> Lindley and Hutton	Lycopsids	Six-Sillons Member (Upper)	Undetermined	Edouard Member (Upper)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Ulodendron minus</i> Lindley and Hutton	Lycopsids	Olympe Member (Lower)	Undetermined	Chandeleur Member (Middle)	Undetermined	Zeiller (1888, p. 691); Corsin and Corsin (1970, pp. 231–232)
<i>Urnatopteris herbacea</i> Boulay	Non-marattialean ferns	Modeste Member (Lower)	Douai, pit Lemay, coal seam undetermined	Edouard Member (Lower)	Liévin, pit N° 3, François	Danzé (1956, pp. 233–234); Buisine (1961, p. 93)
<i>Urnatopteris tenella</i> Brongniart	Non-marattialean ferns	Meunière Member (Lower)	Valenciennes, pit Renard, coal seam undetermined	Ernestine Member (Upper)	Lens, pit N° 8, coal seam undetermined	Danzé (1956, p. 240)
<i>Urnatopteris</i> sp. Bertrand	Non-marattialean ferns	Modeste Member (Upper)	Douai, pit St. Réne, Modeste	NA	NA	Bertrand (1914, p. 219)
<i>Zeilleria delicatula</i> Sternberg	Non-marattialean ferns	Modeste Member (Lower)	Lens, pit N° 10, coal seam undetermined	Six-Sillons Member (Middle)	Undetermined	Danzé (1956, p. 250)
<i>Zeilleria frenzli</i> Stur	Non-marattialean ferns	Chandeleur Member (Upper)	Douai, pit Notre-Dame, coal seam undetermined	Ernestine Member (Upper)	Dourges, pit N° 7, Elisabeth	Danzé (1956, p. 257)
<i>Zeilleria cf. hymenophylloides</i> Kidston	Non-marattialean ferns	Chandeleur Member (Lower)	Dourges, pit N° 2, coal seam undetermined	NA	NA	Danzé (1956, p. 260)

Table S1. Continued.

Taxon	Plant group	Temporal distribution				References
		FAD	Fossil site	LAD	Fossil site	
<i>Zeilleria cf. rhodaeformis</i> Gothan	Non-marattialean ferns	Meunière Member (Lower)	Undetermined	Meunière Member (Upper)	Undetermined	Danzé (1956, p. 261)

## References

- Bertrand, P., 1914. Les zones végétales du terrain houiller du Nord de la France. Leur extension verticale par rapport aux horizons marins. *Annales de la Société Géologique du Nord* 43, 208–254.
- Bouroz, A., 1969. Le Carbonifère du Nord de la France. *Annales de la Société Géologique du Nord* 89, 47–65.
- Brousmiche, C., 1977. Considérations sur *Discopteris occidentalis* Gothan 1954 (*Pteridophyta* du Westphalien d'Europe occidentale). *Geobios* 10 (2), 251–273.
- Brousmiche, C., 1982. Sur la synonymie de *Crossotheca boulayi* Zeiller, 1886–88 et *Crossotheca bourozii* Danzé, 1956 avec l'espèce-type du genre: *Crossotheca crepinii* Zeiller, 1883: Une nouvelle interprétation de la fructification. *Geobios* 15 (5), 679–703.
- Brousmiche, C., 1983. Les fougères sphénoptéridiennes du bassin houiller Sarro-Lorrain. Publication, Société Géologique du Nord 10, 1–480.
- Buisine, A., 1961. Contribution à l'étude de la flore du terrain houiller. Les Aléthoptéridées du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (4), 1–317.
- Cleal, C.J., 2008a. Palaeofloristics of Middle Pennsylvanian lyginopteridaleans in Variscan Euramerica. *Palaeogeography, Palaeoclimatology, Palaeoecology* 261 (1–2), 1–14.
- Cleal, C.J., 2008b. Palaeofloristics of Middle Pennsylvanian medullosaleans in Variscan Euramerica. *Palaeogeography, Palaeoclimatology, Palaeoecology* 268 (3–4), 164–180.
- Corsin, P., 1962. Caractéristiques paléobotaniques des faisceaux du terrain houiller du Nord de la France. *Comptes Rendus de l'Académie des Sciences, Paris* 254, 792–795.
- Corsin, P., Corsin, P., 1970. Un siècle et demi de Paléobotanique dans le Nord de la France. *Annales de la Société Géologique du Nord* 90, 223–252.
- Crookall, R., 1966. Fossil plants of the Carboniferous rocks of Great Britain [Second section]. Part 2. *Memoirs of the Geological Survey of Great Britain. Palaeontology* 4, 217–354.
- Dalinal, A., 1960. Contribution à l'étude des Pécoptéridées. Les *Pecopteris* du Bassin Houiller du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (3), 1–222.
- Danzé, J., 1956. Contribution à l'étude des *Sphenopteris*. Les fougères Sphénoptéridiennes du bassin houiller du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (2), 1–568.
- Danzé-Corsin, P., 1953. Contribution à l'étude des Marioptéridées. Les *Mariopteris* du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (1), 1–269.
- Laveine, J.-P., 1967. Contribution à l'étude de la flore du terrain houiller. Les Neuroptéridées du Nord de la France. *Études Géologiques pour l'Atlas Topographie Souterraine* 1 (5), 1–344.
- Laveine, J.-P., 1987. La flore du bassin houiller du Nord de la France, Biostratigraphie et méthodologie. *Annales de la Société Géologique du Nord* 106, 87–93.
- Laveine, J.-P., Goubet, P., 1995. Mise au point sur *Palaeoweichselia defrancei* (ptéridospermée du Carbonifère), à partir d'un bel échantillon récolté dans le bassin houiller du nord de la France. *Sciences*

- Géologiques, Bulletins et Mémoires 48, 21–47.
- Laveine, J.-P., Coquel, R., Loboziak, S., 1977. Phylogénie générale des Calliptéridiacées (Pteridospermopsida). *Geobios* 10 (6), 757–847.
- Laveine, J.-P., Coquel, R., Brousmiche, C., 1978. L'espece *Pecopteris simoni* (Zeiller, 1886–1888) synonyme postérieur de *Palaeoweichselia defrancei* (Brongniart, 1828). *Geobios* 11 (5), 755–759.
- Loboziak, S., 1971. Les micro- et megaspores de la partie occidentale du bassin houiller du Nord de la France. *Palaeontographica Abteilung B* 132, 1–127.
- Thomas, B.A., Appleton, P., Cleal, C.J., Seyfullak, L.J., 2020. The distribution of plant fossils and their palaeoecology in Duckmantian (Bashkirian, Lower Pennsylvanian) strata at Brymbo, North Wales, UK. *Geological Journal* 55 (4), 3179–3207.
- van Amerom, H.W.J., 1975. Die eusphenopteridischen Pteridophyllen aus der Sammlung des Geologischen Bureaus in Heerlen, unter besonderer Berücksichtigung ihrer Stratigraphie bezüglich des südlimburger Kohlenreviers. *Mededelingen Rijks Geologische Dienst Series, C-III-1* 7, 1–202.
- Wagner, R.H., Álvarez-Vázquez, C., 2008. A revision of the Lower Pennsylvanian *Alethopteris lonchitica* (auctoreum) and its identity with *Alethopteris urophylla*. *Revista Española de Paleontología* 23 (2), 157–192.
- Zeiller, R., 1888. Bassin houiller de Valenciennes: description de la flore fossile. *Études des Gîtes Minéraux de la France*, Paris, 731 pp.