



ELSEVIER

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com



General Palaeontology, Systematics and Evolution (Taphonomy and Fossilisation)

Turonian flora from the fossiliferous flints of Châtelleraut (western France)



Flore turonienne des silex fossilifères de Châtelleraut (Ouest de la France)

Jean-David Moreau^{a,b,*}, Jean Airvaux^c, David Hérisson^d^a CNRS UMR 6282 Biogéosciences, université de Bourgogne-Franche-Comté, 6, boulevard Gabriel, 21000 Dijon, France^b Musée du Gévaudan, 48000 Mende, France^c Independent Researcher, 76, route de Bouresse, Mazerolles, 86320 Lussac-les-Châteaux, France^d CNRS-UMR 7194, département de préhistoire, Muséum national d'histoire naturelle, Institut de paléontologie humaine, 1, rue René-Panhard, 75013 Paris, France

ARTICLE INFO

Article history:

Received 19 June 2017

Accepted after revision 31 July 2017

Available online 20 September 2017

Handled by Didier Néraudeau et Sylvain Charbonnier

Keywords:

Plants

Conifers

Angiosperms

Marine invertebrates

Flints

Upper Cretaceous

Vienne

ABSTRACT

Three new localities yielding fossiliferous flints are reported from the Châtelleraut area (Vienne, western France). They include one archaeological site (La Grande Vallée) and two zones with alterite deposits (L'Aunas and Les Bariollières). Broken surfaces of flint nodules show co-occurrence of marine invertebrates such as bryozoans, echinoids (*Micraster Agassiz*, *Orthopsis Cotteau*), gastropods (*Acteonella* d'Orbigny), rudists, and sponges. The association of *Acteonella*, *Micraster* and *Orthopsis* confirms the Turonian age (Upper Cretaceous) of the fossil assemblage. The marine invertebrates co-occur with plant macroremains including fragments of conifer leafy axes such as *Brachyphyllum?* Brongn., *Frenelopsis* (Schenk) emend. J. Watson and *Geinitzia* Endl., as well as fragments of angiosperm leaves. Plant remains are preserved as siliceous permineralizations, showing the gross morphology and all tissues in three dimensions. The fossil assemblage suggests that sediments were deposited proximally along the shoreline in shallow environment influenced by both continental and marine inputs. This coastal area was close to a conifer-dominated forest ecosystem, *Geinitzia* being probably one of the main components of the flora.

© 2017 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.

R É S U M É

Trois nouvelles localités livrant des silex fossilifères sont signalées dans le secteur de Châtelleraut (Vienne, Ouest de la France). Elles incluent un site archéologique (La Grande Vallée) et deux zones à dépôts d'altérites (L'Aunas and Les Bariollières). Les surfaces brisées des nodules de silex montrent une co-occurrence d'invertébrés marins tels que des bryozoaires, des échinides (*Micraster Agassiz*, *Orthopsis Cotteau*), des éponges, des gastéropodes (*Acteonella* d'Orbigny) et des rudistes. L'association d'*Acteonella*, de *Micraster* et d'*Orthopsis* confirme l'âge Turonien (Crétacé supérieur) de l'assemblage fossile. Aux invertébrés marins s'ajoutent des macrorestes végétaux, qui correspondent à des fragments d'axes feuillés de conifères, dont *Brachyphyllum?* Brongn., *Frenelopsis* (Schenk) emend. J. Watson et *Geinitzia* Endl., ainsi que des fragments de feuilles d'angiospermes. Les restes de

Mots clés :

Plantes

Conifères

Angiospermes

Invertébrés marins

Silex

Crétacé supérieur

Vienne

* Corresponding author. CNRS UMR 6282 biogéosciences, université de Bourgogne-Franche-Comté, 6, boulevard Gabriel, 21000 Dijon, France.
E-mail address: jean.david.moreau@gmail.com (J.-D. Moreau).

plantes sont préservés sous forme de perminéralisations siliceuses, montrant une préservation en trois dimensions de la morphologie générale et des tissus. L'assemblage fossile suggère que les sédiments ont été déposés le long d'une côte, dans un environnement proximal peu profond, influencé à la fois par des apports marins et terrestres. Cette zone côtière était proche d'un écosystème forestier à conifères, où *Geinitzia* était probablement une des composantes principales de la flore.

© 2017 Académie des sciences. Publié par Elsevier Masson SAS. Tous droits réservés.

1. Introduction

Over recent decades, more than fifteen localities yielding mid-Cretaceous (Albian–Cenomanian) plant beds were reported from western France (e.g., Berthelin and Pons, 1999; Girard et al., 2013; Pons, 1979; Saint-Martin et al., 2013; Valentin et al., 2014). They are mainly located in the Aquitaine Basin, in the Charente and Charente-Maritime departments (Coiffard et al., 2009; Gomez et al., 2004, 2008; Néraudeau et al., 2005, 2009, 2013; Perrichot, 2005). Commonly, fossiliferous beds consist of clay and lignite providing abundant plant macroremains preserved as impressions or compressions with or without cuticles. More rarely, Albian–Cenomanian plants are preserved as siliceous permineralizations showing details of inner tissues (Moreau et al., 2014a, 2014b, 2015). By contrast with mid-Cretaceous, the Upper Cretaceous plant beds are rarer in western France. Only three Turonian–Coniacian localities were studied, Sainte-Mondane in Dordogne (Néraudeau et al., 2016), then Claix and Torsac in Charente (Moreau et al., 2016; Néraudeau, 2014; Fig. 1). Remains from Sainte-Mondane consist of isolated foliar cuticles whereas those from Claix and Torsac are permineralized.

Here, we report three new localities yielding Turonian plant-bearing flints from the Châtelleraut area. The Upper Cretaceous Laurasian floras being weakly documented, this paper aims to describe these terrestrial plants, compare them with pre-Turonian and Turono–Coniacian floras, and discuss palaeoenvironmental/palaeoecological insights.

2. Geographical and geological setting

The study area is located in the northern part of the Seuil du Poitou that corresponds to the transition between the Paris Basin and the Aquitaine Basin (Vienne department, western France; Fig. 1). The plant-bearing flints described in the present paper were all collected in nodules coming from the upper Turonian deposits of the Châtelleraut area. These deposits consist of a residual formation that constitutes the top of cuestas and plateaus (Bourgueil et al., 1976; Médioni, 1974). It displays yellow to red clay containing yellow to brown flints and decalcified rocks. This formation is not well developed and do not exceed some metres in thickness (Bourgueil et al., 1976). Bioclasts are not abundant into the flints, being limited to some bivalves, bryozoans, echinoids and siliceous sponges (Alcaydé and Joubert, 1987; Bourgueil et al., 1976; Carioux and Joubert, 1989). Plants come from three localities including one archaeological site and two

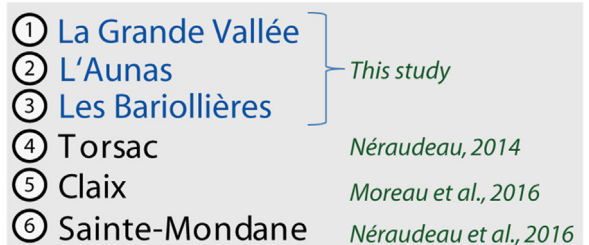
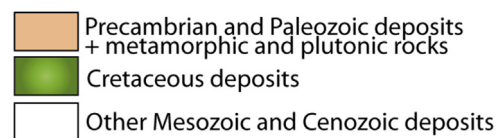
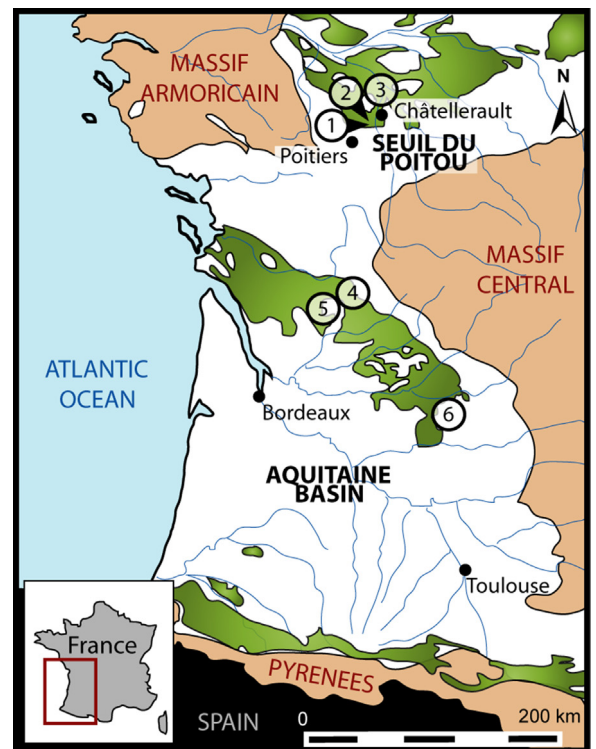


Fig. 1. Geological map of western France showing position of the Turonian–Coniacian plant localities included the three new sites from the Châtelleraut area (La Grande Vallée, Les Bariollières, and L'Aunas).

Fig. 1. Carte géologique de l'Ouest de la France, indiquant la position des localités à plantes turono-coniaciennes, incluant les trois nouveaux sites du secteur de Châtelleraut (La Grande Vallée, Les Bariollières et L'Aunas).

alterite deposits. Most of the specimens presented in this paper were collected from archaeological layers from La Grande Vallée that was discovered by one of us (J.A.) in 1995 then excavated between 2006 and 2012 (Hérisson et al., 2012, 2016). This site is located on the upper Turonian alterites which were exploited during the middle Pleistocene for the lithic industry. La Grande Vallée (Colombiers) is located 20 km north-east of Poitiers and 10 km south-west of Châtellerault. Other localities consist of surface deposits with alterites containing upper Turonian flints. Plant-bearing flints were collected by one of us (J.A.) in the alterites of L'Aunas (Colombiers) in 1974 and Les Bariollières (Ingrandes) in 1980. L'Aunas is located 1 km west of Colombiers. Les Bariollières is located near the village of Ingrandes, 5 km north of Châtellerault. Collecting in 1980 in areas such as Les Douris, near the village of Leugny, 15 km north-east of Châtellerault, provided evidence of marine invertebrates.

3. Material and methods

Fossil plants are present on the broken surfaces of flints. Plant-bearing flints are irregular in shape and do not exceed 20 cm in diameter. The plant inclusions are rare and dispersed inside the matrix and do not form rich accumulations. They co-occur with marine invertebrates inside flints, including bryozoans, gastropods such as *Acteonella* d'Orbigny, regular echinoids such as *Orthopsis* Cotteau, spatangoid echinoids such as putative *Micraster* Agassiz, sponge spicules and undetermined rudists (Figs. 2–3). Here, the association of *Acteonella*, *Micraster* and *Orthopsis* confirms the Turonian age of the plant assemblage contained inside flints (see Bourgueil et al., 1976; Fig. 3). Plant remains consist of leafy axes of conifers (in the three localities), fragments of angiosperms leaves (only at L'Aunas; Figs. 4–6) and wood showing borrows (Fig. 2D–E). Plants are preserved in 3D and completely permineralized in sil-

ica, preserving most of tissues (Fig. 6D–E). No isolated cuticle was found. The flints are housed in the Jean-Airvaux collection of the “Musée national de préhistoire”, Les Eyzies-de-Tayac-Sireuil, France.

4. Systematic palaeontology

4.1. Conifers

Family – Cheirolepidiaceae

Genus – *Frenelopsis* Schenk, 1869 *emend.* J. Watson, 1976

Frenelopsis sp. (Fig. 4A–F)

Material. 2 specimens: CLM.3b, CLM.5.

Locality. L'Aunas

Description. The best preserved specimen is 81 mm long, 48 mm wide and shows up to twice branched leafy axes. Branches arise at up to 30° (Fig. 4A–C). The branches consist of successive elongated, flattened, 11–26 mm long, and 4–5 mm wide internodes (Fig. 4D–F). The longest branch is 65 mm long and formed by four successive internodes. Each internode is formed by one whorl of three proximally fused leaves. Free parts of the leaves are only visible distally. They form three tiny tips (Fig. 4D).

Remarks. Although *Frenelopsis* was documented in several Albian–Cenomanian localities from western France (e.g., Lecoindre and Carpentier, 1938), remains were commonly limited to isolated internodes preserved as cuticle that are nearly never connected between them. The specimen from l'Aunas consists of one of the most complete leafy axes of *Frenelopsis* from western France.

Family – *Incertae sedis*

Genus – *Brachyphyllum?* Brongn., 1828

Brachyphyllum? sp. (Fig. 5A–B)

Material. 1 specimen: GDV.1.

Locality. La Grande Vallée

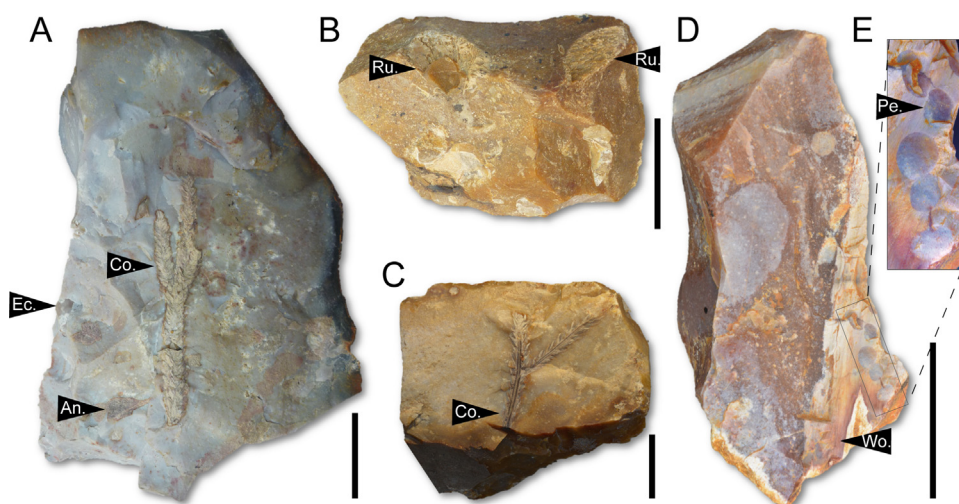


Fig. 2. A–E: flints showing diverse fossil inclusions including marine invertebrates and terrestrial plants. An.: angiosperm; Co.: conifer; Ec.: echinoid; Ru.: rudist; Wo.: wood showing perforations (Pe.). A: CLM.1; B: GDV.6; C: BAR.1; D–E: GDV.3. All scale bars: 5 cm.

Fig. 2. A–E : silex montrant diverses inclusions fossiles dont des invertébrés marins et des plantes terrestres. An. : angiosperme; Co. : conifère; Ec. : échinide ; Ru. : rudiste ; Wo. : bois montrant des perforations (Pe.). A : CLM.1 ; B : GDV.6 ; C : BAR.1 ; D–E : GDV.3. Barres d'échelle : 5 cm.

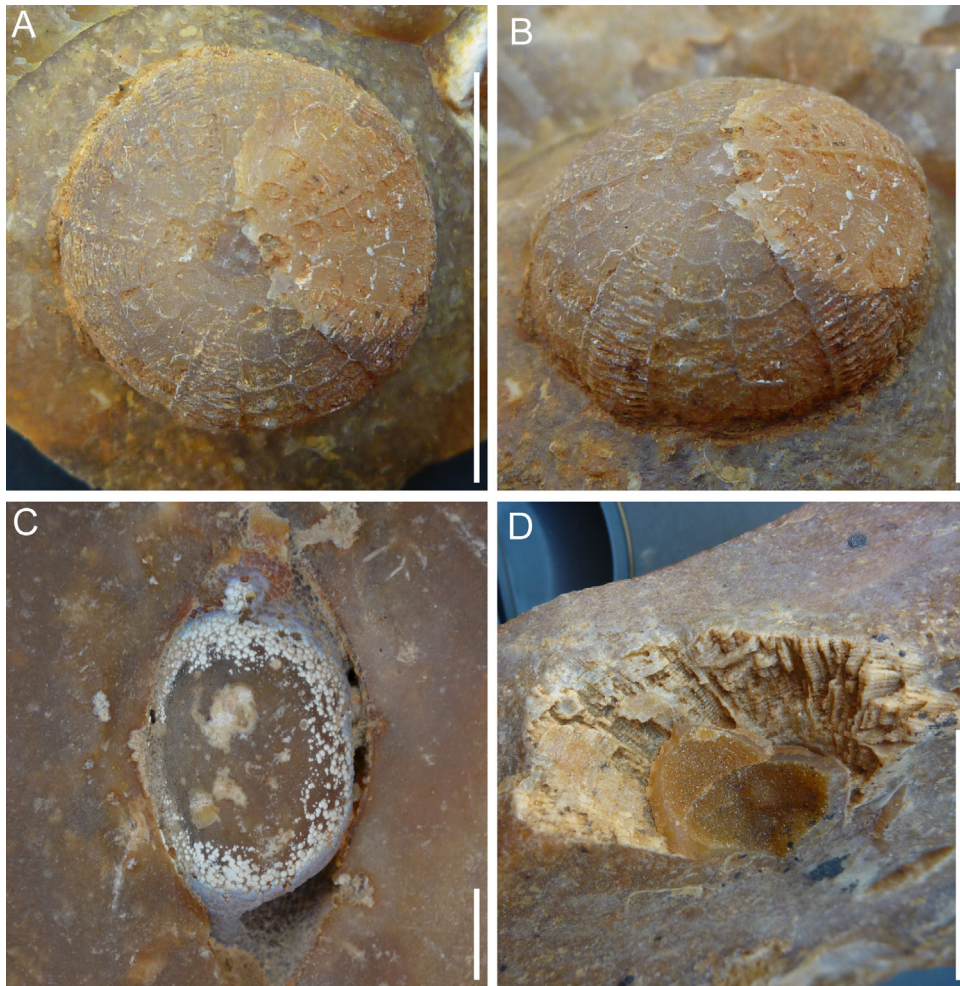


Fig. 3. Marine invertebrates from the Turonian flints of Châtellerault. A–B: regular echinoid: *Orthopsis*, GDV.2; C: gastropod: *Acteonella*, DOU.1; D: undetermined rudist, GDV.6. All scale bars: 1 cm.

Fig. 3. Invertébrés marins des silex turoniens de Châtellerault. A–B : échinide régulier : *Orthopsis*, GDV.2 ; C : gastéropode : *Acteonella*, DOU.1 ; D : rudiste indéterminé, GDV.6. Barres d'échelle : 1 cm.

Description. A unique remain consists of slender, once-branched leafy axis, 29 mm long, and 6 mm in diameter. It bears tiny leaves that seem to be helically arranged and nearly as broad as they are long (up to 5 mm). They are appressed to the stem, abaxially convex, and partially overlapping. The leaf apex forms a small blunt tip, curved inward to the stem axis.

Remarks. *Brachyphyllum*? seems to be rare in the plant assemblage of Châtellerault. An observation of a clear helically arrangement and a rhombic shape of leaves should be necessary to undoubtedly identify the genus *Brachyphyllum*.

Genus – *Geinitzia* Endl., 1847

Geinitzia sp. (Fig. 6A–E)

Material. 7 specimens: BAR.1, CLM.1a, CLM.2, CLM.3a, GDV.4a–GDV.4b, GDV.5.

Localities. Les Bariollières, La Grande Vallée, L'Aunas

Description. Shoots are up to twice branched. Branches arise at up to 45°. The longest specimen is 88 mm long. Shoots are up to 15 mm in diameter, strait to slightly curve.

Leaves are helically arranged, elongated, up to 13 mm long and 3 mm wide (Fig. 6A–E). Leaves show a long free part that forms an acute angle of up to 70° with main axis of the shoot (Fig. 6A–D). The leaf margin is entire (Fig. 6E). The apex of leaves is acute and slightly curved inward (Fig. 6A–E). In cross section, leaves are quadrangular in shape (Fig. 6C).

Remarks. Leafy axes of *Geinitzia* are the most abundant plant remains from Les Bariollières, La Grande Vallée, and L'Aunas. Elongated, lanceolate, helically arranged leaves forming an acute angle with the main axis of the shoots are known among several Cretaceous conifers such as *Cunninghamites* Presl in Sternberg, *Elatocladus* T. Halle, *Geinitzia* and *Pagiophyllum* Heer emend. T. M. Harris. The genus *Geinitzia* differs from *Elatocladus* by the absence of contraction at the leaf base (Kvaček, 1999). Leaves of *Geinitzia* differ from *Cunninghamites* in having a triangular to quadrangular form in cross section, not needles flattened (Herman and Kvaček, 2010; Kvaček, 1999).

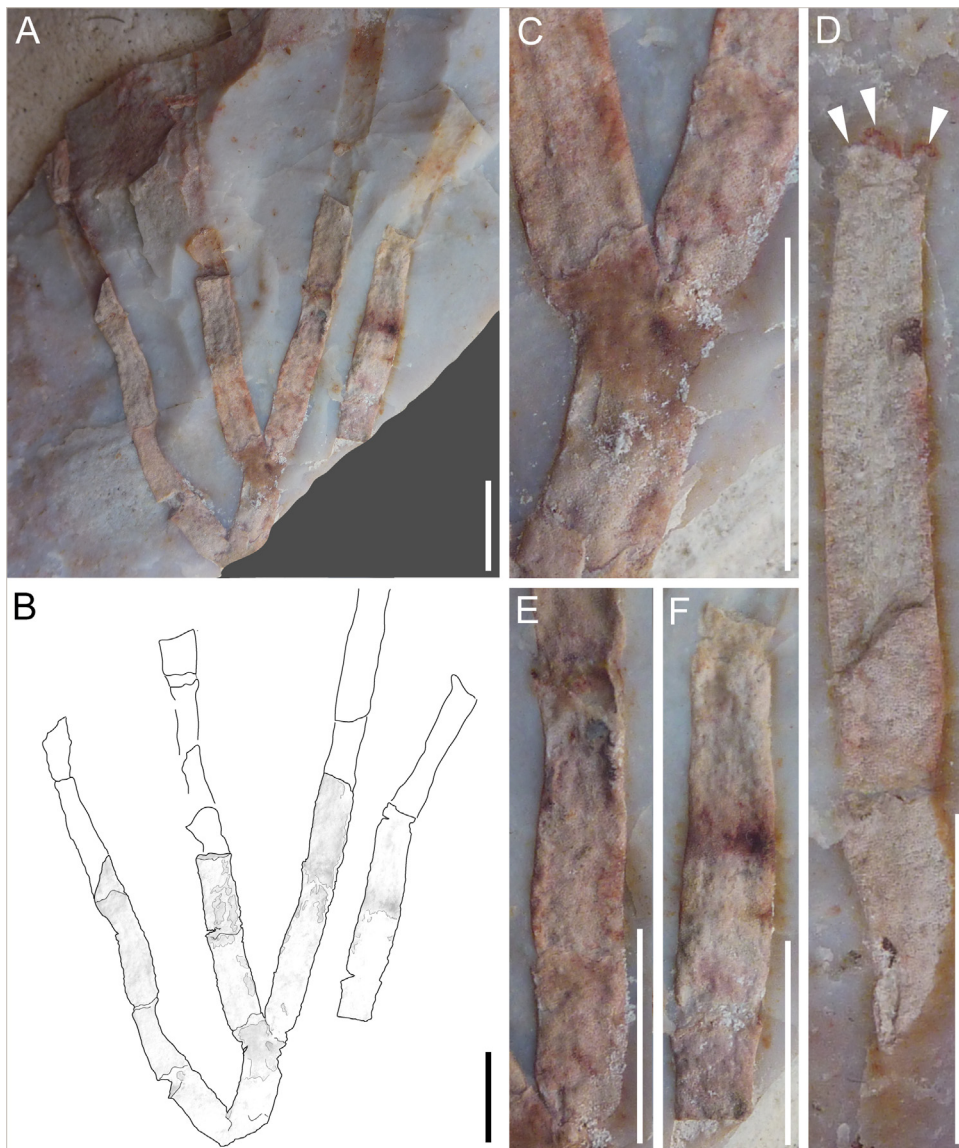


Fig. 4. A–F: leafy axes of *Frenelopsis* (A) and interpretative sketch (B) showing branched twigs (C), and successive elongated, flattened internodes (D–F). Arrows indicate tiny tips that correspond to the apical free parts of leaves (A–C, E–F: CLM.5; D: CLM.3b). All scale bars: 1 cm.

Fig. 4. A–F : axes feuillés de *Frenelopsis* (A) et schéma interprétatif (B) montrant des rameaux ramifiés (C), puis des gaines foliaires successives, allongées et aplaties (D–F). Les flèches indiquent de petites pointes qui correspondent aux parties apicales libres des feuilles (A–C, E–F : CLM.5 ; D : CLM.3b). Barres d'échelle : 1 cm.

4.2. Angiosperms

Family – *Incertae sedis*

Genus – *Incertae sedis* (Fig. 6F–G)

Material. 2 specimens: CLM.1b, CLM.1c.

Locality. L'Aunas

Description. The specimens consist of two lamina fragments. Largest specimen is 26 mm long and 13 mm wide. Leaves are petiolate and their basis is cuneate (Fig. 6F–G). Petiole is up to 3 mm wide. Margins of lamina are not clearly visible but seem to be entire. The primary venation is only partially visible and pinnate.

Remarks. Leaves are greatly fragmented. The weak preservation does not allow relevant comparisons with coeval taxa.

5. Discussion

5.1. Comparisons

Pre-Turonian floras. *Brachyphyllum*, *Frenelopsis* and *Geinitzia*, as well as angiosperm macroremains are unknown in the rare Hauterivian–Barremian plant localities from western France (e.g., Angeac in Charente;

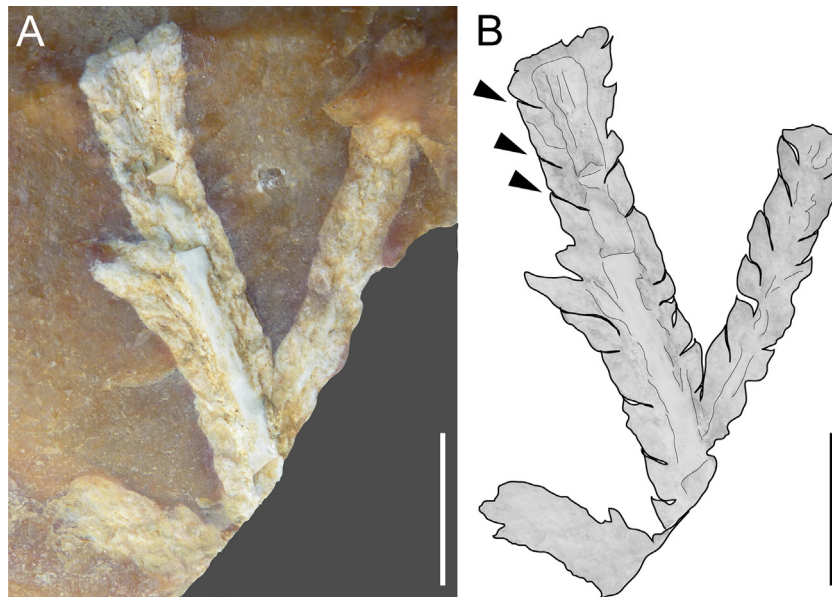


Fig. 5. Leafy axis of the conifer *Brachyphyllum*? (A) and interpretative sketch (B) showing leaves appressed to the stem and partially overlapping; GDV.1. Arrows indicate apex of leaves. All scale bars: 1 cm.

Fig. 5. Axe feuillé du conifère *Brachyphyllum*? (A) et schéma interprétatif (B) montrant les feuilles plaquées contre l'axe de la tige et partiellement recouvrantes ; GDV.1. Les flèches indiquent l'apex des feuilles. Barre d'échelle : 1 cm.

Néraudeau et al., 2012). Among the Albian–Cenomanian plant-beds from western France, only two of them yielded an association of *Brachyphyllum*, *Frenelopsis* and *Geinitzia*: the lower Cenomanian clay from the Brouillard quarry in Maine-et-Loire (Alvarez-Ramis et al., 1981; Néraudeau et al., 2013) and the Cenomanian siliceous nodules from the Archingeay–Les Nouillers quarry in Charente-Maritime (Moreau et al., 2014a, 2014b). However, remains ascribed to these taxa were individually described from other localities. Isolated cuticles of *Frenelopsis alata* (K. Feistmantel) E. Knobloch were mentioned in the Albian–Cenomanian lignites from several Charentese localities such as the Puy-Puy quarry, at Tonnay-Charente, Fouras, the Aix Island, and the Madame Island (Gomez et al., 2004). Microscopic observations of the cuticle allow the species to be determined based on numerous papillae on epidermal cells (Gomez et al., 2004). Cuticles of *Frenelopsis* were also described from the Cenomanian clays of Aude (Girard et al., 2013) and Vienne (Lecointre and Carpentier, 1938). In western France, isolated cuticles ascribed to *Brachyphyllum* were observed in the Cenomanian lignites from Archingeay–Les Nouillers (Gomez et al., 2008) and the Aix Island (Néraudeau et al., 2009) in Charente-Maritime, then Jaunay-Clan in Poitou-Charentes (Valentin et al., 2014). Imprints and impressions/compressions of the conifer *Geinitzia reichenbachii* (Geinitz) Hollick and Jeffrey were reported from the lower Cenomanian of the Puy-Puy quarry (Néraudeau et al., 2005).

Pre-Turonian clays from several French localities yielded leaves of angiosperms (Gomez et al., 2004; Valentin et al., 2014). However, only rare of them were studied (Coiffard et al., 2009) and most of them remains undescribed. We may notice that angiosperm remains preserved inside pre-Turonian siliceous nodules are uncommon in the

Aquitaine Basin (e.g., Cenomanian flints of Archingeay–Les Nouillers).

Turono-Coniacian floras. By contrast with Albian–Cenomanian floras, *Brachyphyllum*, *Frenelopsis*, *Geinitzia* and angiosperm leaves were rarely described from the Turonian-Coniacian localities of western France. Turonian-Coniacian flora showing the co-occurrence of the three conifers and angiosperm leaves is only known in the flint nodules from Claix, Charente (Moreau et al., 2016; Fig. 1). Similarly to the flora from Châtellerault, the plant macroremains from Claix show a *Geinitzia*-dominated assemblage. We may notice that the Turonian clays from Dordogne yielded isolated cuticles of *Brachyphyllum* and *Frenelopsis* (Néraudeau et al., 2016). *Geinitzia* was reported from the Turonian of Simeyrols in Dordogne (Saint-Martin et al., 2013). Then *Brachyphyllum* was also mentioned in the Turono-Coniacian flints from Torsac in Charente (Néraudeau, 2014). Leaves of angiosperms were observed in the flints from Claix and Torsac (Moreau et al., 2016; Néraudeau, 2014).

5.2. Palaeoenvironment

The association of marine invertebrates and terrestrial plants suggests that sediments were deposited proximally along the shoreline in environment showing both continental and marine inputs. The morphology of the borings (Fig. 2D) observed in wood share similarities with holes of xylophagous bivalves which are well-known in the mid-Cretaceous brackish to shallow marine palaeoenvironments from Charente-Maritime (e.g., Perrichot, 2005). The borings of xylophagous bivalves suggest that wood remained a long time on the surface of substratum before to be buried (several months or years). The coastal area was

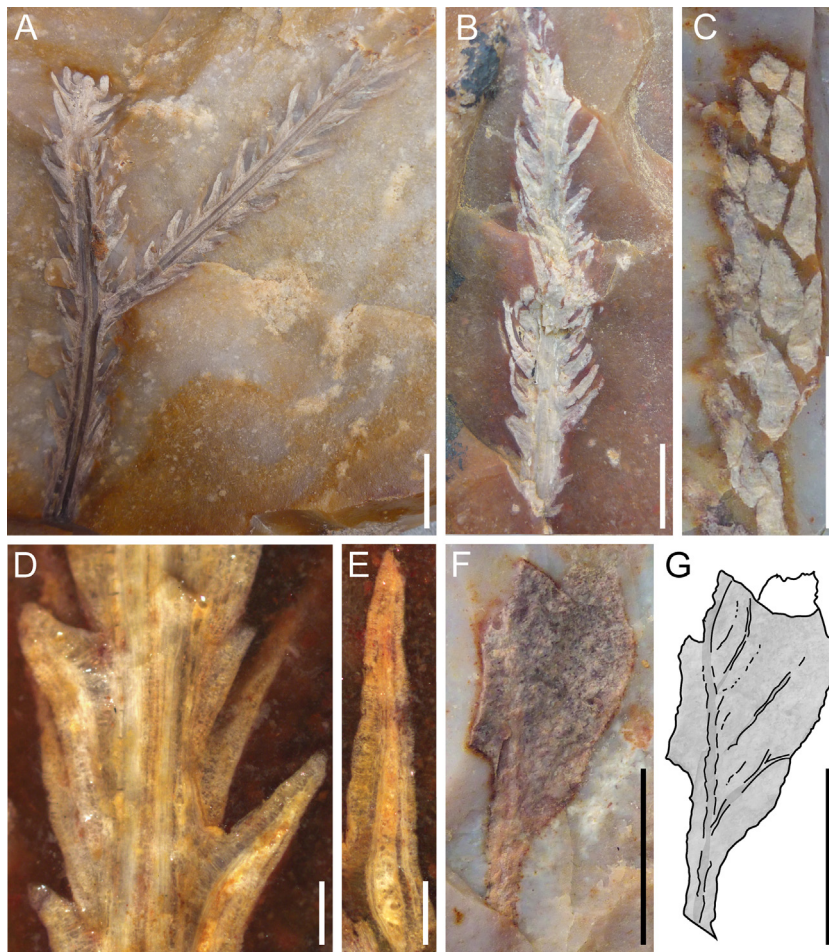


Fig. 6. A–E: *Geinitzia*; leafy axes (A–B; A: BAR.1; B: GDV.5), detail of leaves in transversal section (C: CLM.2) and in longitudinal section (D–E: GDV.4a) showing preservation of tissues (D: GDV.4a). F–G: fragment of angiosperm leaf (F: CLM.1b) and interpretative sketch (G). Scale bars: A–C and F–G = 1 cm; D–E = 1 mm.

Fig. 6. A–E : *Geinitzia* ; axes feuillés (A–B ; A : BAR.1 ; B : GDV.5), détail de feuilles en coupe transversale (C : CLM.2) et coupe longitudinale (D–E : GDV.4a), montrant la préservation de tissus (D : GDV.4a). F–G : fragment d'une feuille d'angiosperme (F : CLM.1b) et schéma interprétatif (G). Barres d'échelle : A–C and F–G = 1 cm ; D–E = 1 mm.

close to a conifer-dominated forest ecosystem, *Geinitzia* being probably one of the main components of the flora. Although *Geinitzia* was reported from inland environment with moderate marine inputs to open to the sea areas (Moreau et al., 2016; Néraudeau et al., 2005), this conifer was probably adapted to survive in harsh and instable environments such as coastal area exposed to hot, dry conditions. As previously demonstrated, the Cretaceous conifers from western France display a large set of xerophytic features that might well accommodate them to a broad range of habitats (e.g., Moreau et al., 2015). Concerning the flints from Châtellerault, the hypothesis of a coastal environment is also supported by other conifers co-occurring with *Geinitzia*. In fact, *Brachyphyllum* and *Frenelopsis* show xerophytic features generally present among plants inhabiting Cretaceous terrestrial environments highly influenced by marine or haline inputs (Barale, 1997; Gomez et al., 2008; Néraudeau et al., 2005, 2009; Thévenard et al., 2005).

Acknowledgements

We thank Jean-François Baratin for his contribution during excavation of La Grande Vallée. The excavation of La Grande Vallée was supported by a grant from the “Service régional de l'archéologie du Poitou-Charentes”, which the authors gratefully acknowledge. We thank Didier Néraudeau for the discussions and the determination of marine invertebrates. We thank the two anonymous reviewers who provided useful comments and suggestions.

References

- Alcaydé, G., Joubert, J.-M., 1987. Notice explicative de la carte géologique de Lençloître à 1/50 000, carte n° 540. Bur. Rech. Geol. Min., Orléans, 35.
- Alvarez-Ramis, C., Biondi, E., Desplats, D., Hughes, N.F., Koeniguer, J.-C., Pons, D., Rioult, M., 1981. Les végétaux (macrofossiles) du Crétacé moyen de l'Europe occidentale et du Sahara. Végétations et paléoclimats. Cretaceous Res. 2, 339–359.

- Barale, G., 1997. Les stratégies adaptatives de quelques végétaux du Jurassique/Crétacé inférieur de la Province européenne. *Geobios* 2, 17–22.
- Berthelin, M., Pons, D., 1999. Signification des caractères partagés entre Bennettiales et Cycadales. Implications de la découverte d'une Cycadale nouvelle du Cénomaniens de l'Anjou (France). *Ann. Paleontol.* 85, 227–239.
- Bourguieu, B., Cariou, E., Moreau, P., Ducloux, J., Teissier, J.-L., 1976. Notice explicative de la carte géologique de Vouneuil-sur-Vienne à 1/50 000, carte n° 567. *Bur. Rech. Geol. Min., Orléans*, 24.
- Cariou, E., Joubert, J.-M., 1989. Notice explicative de la carte géologique de Mirebeau-en-Poitou à 1/50 000, carte n° 566. *Bur. Rech. Geol. Min., Orléans*, 36.
- Coiffard, C., Gomez, B., Thiébaud, M., Kvaček, J., Thévenard, F., Néraudeau, D., 2009. Intramarginal veined Lauraceae leaves from the Albian–Cenomanian of Charente-Maritime (western France). *Palaeontology* 52, 323–336.
- Girard, V., Breton, G., Perrichot, V., Bilotte, M., Le Loeuff, J., Nel, A., Philippe, M., Thévenard, F., 2013. The Cenomanian amber of Fourtoul (Aude, southern France): taphonomy and palaeoecological implications. *Ann. Paleontol.* 99, 301–315.
- Gomez, B., Daviero-Gomez, V., Perrichot, V., Thévenard, F., Coiffard, C., Philippe, M., Néraudeau, D., 2004. Meso- and megaremaines of fossil plants from the Albian–Cenomanian of Charente-Maritime (SW France). *Ann. Paleontol.* 90, 147–159.
- Gomez, B., Coiffard, C., Dépré, E., Daviero-Gomez, V., Néraudeau, D., 2008. Diversity and histology of a plant litter bed from the Cenomanian of Archingeay–Les Nouillers (southwestern France). *C. R. Palevol* 7, 135–144.
- Hérisson, D., Airvaux, J., Lenoble, A., Richter, D., Claud, E., Primault, J., 2012. Le gisement acheuléen de La Grande Vallée à Colombiers (Vienne, France): stratigraphie, processus de formation, datations préliminaires et industries lithiques. *Paleo* 23, 137–154.
- Hérisson, D., Airvaux, J., Lenoble, A., Richter, D., Claud, E., Primault, J., 2016. Between the northern and southern regions of western Europe: The Acheulean site of La Grande Vallée (Colombiers, Vienne, France). *Quat. Int.* 411, 108–131.
- Herman, A.B., Kvaček, J., 2010. Late Cretaceous Grünbach Flora of Austria. *Naturhistorisches Museum Wien, Vienna*, pp. 216 p.
- Kvaček, J., 1999. New data and revision of three gymnosperms from the Cenomanian of Bohemia–*Sagenopteris variabilis* (Velenovský) Velenovský, *Mesenea bohémica* (Corda) comb. nov. and *Eretmophyllum obtusum* (Velenovský) comb. nov. *Acta Mus. Nat. Pragae, Ser. B. Hist. Nat.* 55, 15–24.
- Lecoindre, G., Carpentier, A., 1938. Sur les empreintes de *Frenelopsis* du Cénomaniens provenant du forage de Monts-sur-Guesnes (Vienne). *Bull. Soc. geol. France* 5, 583–586.
- Médioni, R., 1974. Notice explicative de la carte géologique de Châtellerault à 1/50 000, carte n° 541. *Bur. Rech. Geol. Min., Orléans, France*, 38.
- Moreau, J.-D., Néraudeau, D., Gomez, B., Tafforeau, P., Dépré, E., 2014a. Plant inclusions from the Cenomanian flints of Archingeay–Les Nouillers, western France. *Lethaia* 47, 313–322.
- Moreau, J.-D., Néraudeau, D., Gomez, B., Tafforeau, P., Dépré, E., 2014b. Inclusions of conifers, echinoids, foraminifers and sponges in flints from the Cenomanian of Charente-Maritime (France): contribution of synchrotron microtomography. *C. R. Palevol* 13, 455–461.
- Moreau, J.-D., Néraudeau, D., Tafforeau, P., Dépré, E., 2015. Study of the histology of leafy axes and male cones of *Glenrosa carentonensis* sp. nov. (Cenomanian flints of Charente-Maritime, France) using synchrotron microtomography linked with palaeoecology. *PLOS One*, <http://dx.doi.org/10.1371/journal.pone.0134515>.
- Moreau, J.-D., Néraudeau, D., Platel, J.-P., Ravon, A.-L., 2016. Fossiliferous flints (marine invertebrates and terrestrial plants) from the Upper Cretaceous of Claix (Charente). *Ann. Paleontol.*, 103–116.
- Néraudeau, D., 2014. Origine géologique des silex à plantes de Torsac (Charente). *Ann. Sci. Nat. Charente-Maritime* 10, 459–473.
- Néraudeau, D., Vullo, R., Gomez, B., Perrichot, V., Videt, B., 2005. Stratigraphie et paléontologie (plantes, vertébrés) de la série margino-littorale Albien terminal–Cénomaniens basal de Tonnay-Charente (Charente-Maritime, France). *C. R. Palevol* 4, 79–93.
- Néraudeau, D., Vullo, R., Gomez, B., Girard, V., Lak, M., Videt, B., Dépré, E., Perrichot, V., 2009. Amber, plants and vertebrate fossils from the Lower Cenomanian paralic facies of Aix Island (Charente-Maritime, SW France). *Geodiversitas* 31, 13–27.
- Néraudeau, D., Allain, R., Ballèvre, M., Batten, D.J., Buffetaut, E., Colin, J.-P., Dabard, M.P., Daviero-Gomez, V., El Albani, A., Gomez, B., Groshegy, D., Le Loeuff, J., Leprince, A., Martín-Closas, C., Masure, E., Mazin, J.-M., Philippe, M., Pouech, J., Tong, H., Tournepeche, J.-F., Vullo, R., 2012. The Hauterivian–Barremian lignitic bone bed of Angeac (Charente, south-west France): stratigraphical, palaeobiological and palaeogeographical implications. *Cretaceous Res.* 37, 1–14.
- Néraudeau, D., Redois, F., Ballèvre, M., Duplessis, B., Girard, V., Gomez, B., Daviero-Gomez, V., Mellier, B., Perrichot, V., 2013. L'ambre cénomaniens d'Anjou: stratigraphie et paléontologie des carrières du Brouillard et de Hucheloup (Ecouflant Maine-et-Loire). *Ann. Paleontol.* 99, 361–374.
- Néraudeau, D., Saint-Martin, S., Batten, D., Colin, J.-P., Daviero-Gomez, V., Girard, V., Gomez, B., Nohra, Y., Polette, F., Platel, J.-P., Saint-Martin, J.-P., Videt, B., Vullo, R., 2016. Palaeontology of the late Turonian paralic deposits from the Sainte-Mondane Formation (Dordogne SW France). *Geol. Acta* 14, 53–69.
- Perrichot, V., 2005. Environnements paraliques à ambre et à végétaux au Crétacé nord-aquitain (Charentes, Sud-Ouest de la France). *Mem. Geosci. Rennes* 125, 1–310.
- Pons, D., 1979. Les organes reproducteurs de *Frenelopsis alata* (K. Feistm) Knobloch, Cheirolepidiaceae du Cénomaniens de l'Anjou, France. *C. R. 104^e Congrès national des sociétés savantes, Bordeaux. Section Sciences*, 209–231.
- Saint-Martin, J.-P., Saint-Martin, S., Néraudeau, D., 2013. L'ambre associé aux lignites cénomaniens du Sarladais (Dordogne SO France). *Ann. Paleontol.* 99, 289–300.
- Thévenard, F., Gomez, B., Daviero-Gomez, V., 2005. Xeromorphic adaptations of some Mesozoic gymnosperms. A review with palaeoclimatological implications. *C. R. Palevol* 4, 67–77.
- Valentin, X., Gomez, B., Daviero-Gomez, V., Charbonnier, S., Ferchaud, P., Kirejtshuk, A., Licht, A., Néraudeau, D., Vullo, R., Garcia, G., 2014. Plant-dominated assemblage and invertebrates from the Lower Cenomanian of Jaunay-Clan, south-western France. *C. R. Palevol* 13, 443–454.