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The iguanodons of Bernissart (Belgium) are middle Barremian to earliest Aptian in age

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Abstract

The iguanodons of Bernissart (Belgium) have attracted considerable interest since their discovery in the nineteenth century and still remain a reference material. Until now they were relatively poorly dated. This paper deals with the ichthyofauna and the first use of pollen of angiosperms from the dinosaur-bearing sediments to show that they are middle Barremian to earliest Aptian in age.

Key words: Iguanodon, angiosperms, ichthyofauna, Barremian, Bernissart, Mons basin.

Résumé

Les iguanodons de Bernissart (Belgique) ont fait l'objet d'un intérêt considérable depuis leur découverte au dix-neuvième siècle. Ils constituent de nos jours encore un matériel de référence. Ils restent toutefois relativement mal datés. Ce travail résume les informations stratigraphiques de l'ichtyofaune et met en évidence des grains de pollen d'angiospermes dans les sédiments à iguanodons, suggérant un âge barrémien moyen à aptien basal.

Mots-clefs: Iguanodon, angiosperme, ichtyofaune, Barrémien, Bernissart, basin de Mons.

Introduction

The "puits naturel de Bernissart" (Belgium) is famous because of its abundant and very well-preserved fossils: twenty-eight specimens of *Iguanodon bernissartensis* BOULENGER, 1881, including the holotype, one skeleton of *I. atherfieldensis* HOOLEY, 1925, a phalanx of Theropoda *indet.*, thousands of fishes, six turtles, four crocodiles, one salamander, one fragment of a cicada, numerous coprolites, and fragments of plants (see complete references *in* MARTIN & BULTYNCK 1990). The fossils were collected between 1878 and 1881 from the Wealden facies sediments of the Sainte-Barbe Clays Formation at 322 and 356 metres depth in the Sainte-Barbe coalmine.

The dinosaurs of Bernissart were the first complete and articulated dinosaur skeletons ever discovered and still remain one of the greatest accumulations of a single dinosaur taxon (FORSTER 1997). The discovery came at a time when the dinosaur anatomy was still poorly understood and thus considerable advances were made possible in combination with the works of Cope and Marsh in the American mid-West (NORMAN 1987a). Due to their exceptional state of preservation, the iguanodons of Bernissart have been regarded as reference material, allowing several authors to compare them with bones from other sites (e.g. TAQUET 1976; NORMAN 1980, 1986, 1987b; TAQUET & RUSSELL 1999). The age of the iguanodons of Bernissart has been considered as Barremian-Aptian by most contributors (e.g. NORMAN 1986). However, palynomorphs and *Weichselia* from the Iguanodon shaft at Bernissart were thought to indicate approximately a Hauterivian (DELCOURT *et al.* 1963; ANDERSON & HUGHES 1964; DABER 1968, cited *in* ALLEN & WIMBLEDON 1991) and even earliest Valanginian? (ALLEN & WIMBLEDON 1991) age. Until now, no solid stratigraphic argument has been published to constrain the geological age of the iguanodons of Bernissart, which could range from Late Jurassic to Aptian (ROBASZYNSKI *et al.* 2001). We

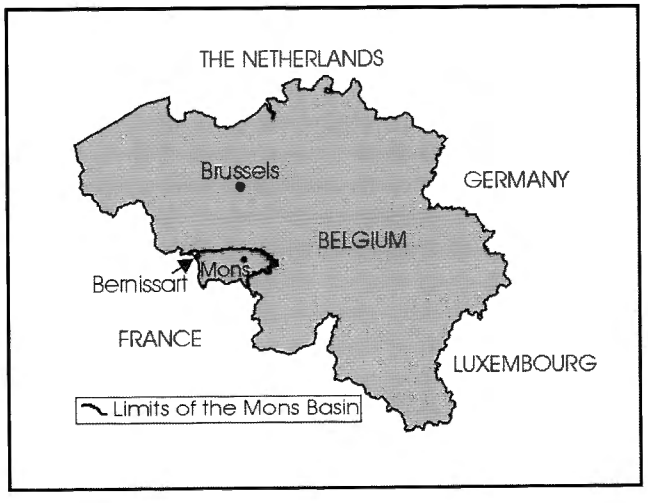

Fig. 1 — Location of Bernissart in the Mons Basin (Belgium).

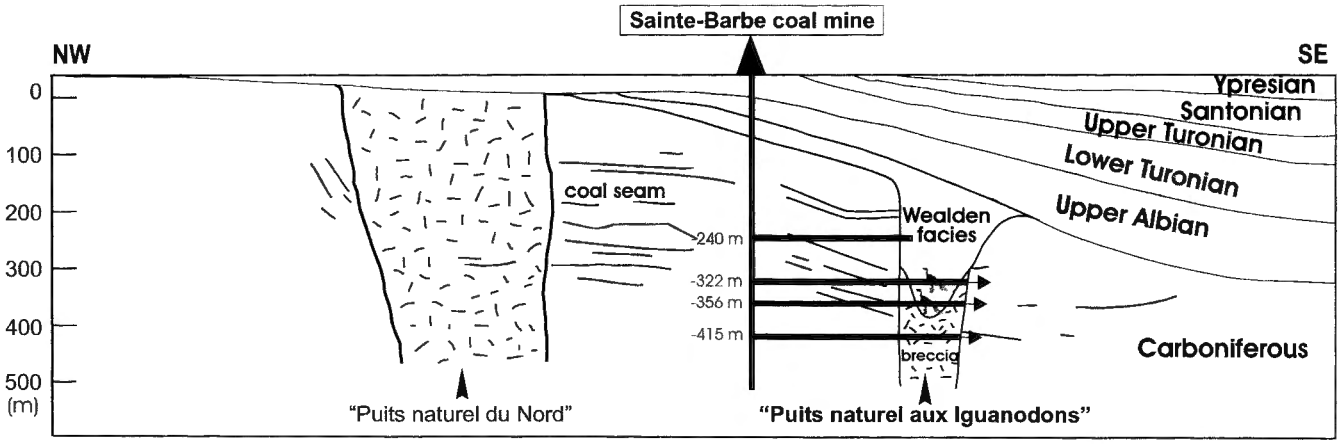

Fig. 2 — Schematic NW-SE section of the northern border of the Mons Basin near the ''Iguanodons pit'' of Bernissart (from DELMER, 1989, modified). The natural pit, formed in the siliciclastic coal-bearing sediments, is covered by Late Albian to Ypresian deposits. The Sainte-Barbe coal mine cut the natural pit at 240, 322, 356 and 415 metres depth.

herein aim to fix this age by using ichthyofauna and angiosperm pollen.

Geological setting

Located in the Mons Basin (Belgium; Fig. 1), the ''puits naturel de Bernissart'' can be considered as a sub-vertical column that stops the continuity of the Carboniferous siliciclastic sediments (DELMER 1989; Fig. 2). The impressive fauna was probably trapped in a marshy environment at the surface and progressively sunk in a natural pit by local and repetitive collapse in response to the space created by the dissolution of deep anhydrites (DELMER 1989; YANS *et al.*, 2005).

Material and method

Sixteen palynological preparations were made from dinosaur-bearing clays and silts collected in 1878-1881 at 322 metres depth in the Sainte-Barbe mine and currently stored at the Royal Belgian Institute of Natural Sciences. Note that only samples from this depth were collected during the excavation; samples from other depths are not available and can therefore not be analysed. The treatment mainly consists in the destruction of the minerals by using fluorhydric acid (70%) followed by a filtration with a 10 µm filter. The specimens illustrated in this work are located with the ''England Finder'' slide. We used both a light microscope and a JEOL 840 A Scanning Electron Microscope. The preparations are stored in the Royal Belgian Institute of Natural Sciences (number: IRSNB Mpal P 103).

Results and discussion

The ichthyofauna discovered at Bernissart contains fifteen actinopterygian species four of which are teleosts (TRAQUAIR 1911, TAVERNE 1981a, 1982, 1999), a proportion typical for the lowermost Cretaceous (Berriasian to Barremian) fish faunas (e.g. FABRE *et al.* 1982; SANZ *et al.* 1988). Since the beginning and during the Aptian stage, the specific representation of ''holosteans'' and teleosts became equal (TAVERNE 1981b; MAISEY 1991). The composition of the fish assemblage of Bernissart therefore suggests a pre-Aptian age (Fig. 3).

The palynomorphs have a continental origin only. Most of them were previously described in the pioneering palynological work of DELCOURT & SPRUMONT (1955): fern spores, pollen of gymnospermous affinity, macrospores, and freshwater algal flora (YANS *et al.* 2004). For the first time we also recognized in these sediments angiosperm pollen, attributed to the biorecord Superret-*croton* of HUGHES *et al.* 1979 (Fig. 4). This morphotype is also known as *Stellatopollis hughesii* PENNY, 1986 *sensu* the morphographical classification of *Sporae dispersae*. Unlike other plant groups, angiosperm pollen had rapid evolutionary rates during the Early Cretaceous, allowing relatively precise dating of continental sediments. In the well dated reference successions of the Weald and Wessex Sub-basins in England, the biorecord Superret-*croton* (equivalent to *Stellatopollis hughesii* PENNY, 1986) is observed only in the MCT (Monosulcate Columellate Tectate) phases 3 to 5 *sensu* HUGHES (1994). By studying the input of marine cysts of dinoflagellates in the reference sections of the Weald and in Wessex (e.g. HARDING 1990), the MCT phases 3 to 5 are dated from middle Barremian to early Aptian (Fig. 3).

The poor percentage and the poor diversity of angiosperm pollen at Bernissart (less than 1 per cent) is typical of the MCT phases 3 and 4; angiosperm pollen is considered as representing about 10 per cent of the palynological assemblage at the MCT phase 5 (HUGHES 1994). The sediments of Bernissart at 322 metres depth therefore correspond to the MCT phases 3 and 4 that are middle Barremian to earliest Aptian in age.

The earliest Aptian age can be only included in the range if we accept that the Vectis Fm. of the Isle of Wight (Wessex Sub-basin, reference section) is partly Aptian, as was suggested by KERTH & HAILWOOD (1988), but was disputed later in ALLEN & WIMBLEDON, 1991. KERTH &

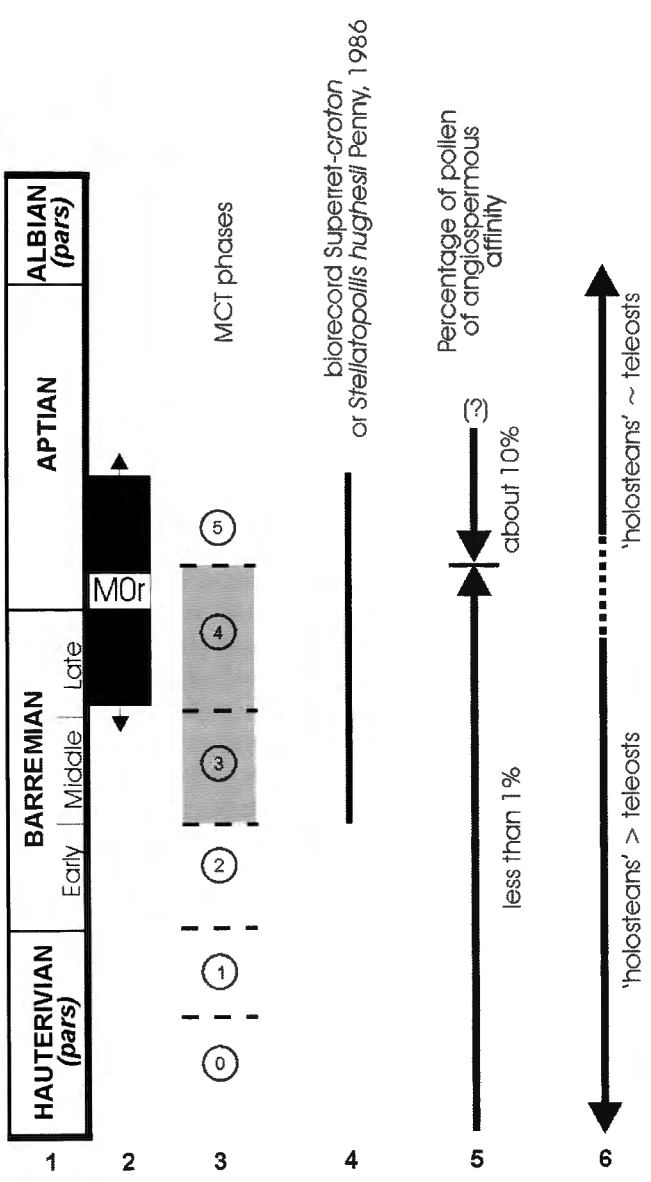

Fig. 3 — Stratigraphic distribution of the Wealden facies sediments from the Sainte-Barbe Clays Formation, at 322 metres depth in the "Cran aux Iguanodons" of Bernissart. 1 = chronostratigraphy; 2 = magnetostratigraphy of the reference section of the Isle of Wight (KERTH & HAILWOOD, 1988) with the M0r (reversal magnetochron zero) diagnostic for the Barremian-Aptian boundary (GRADSTEIN *et al.*, 2004); 3 = succession of the MCT (Monosulcate Columellate Tectate) phases in England (HUGHES, 1994); 4 = stratigraphic distribution of the biorecord Superret-*croton* defined by HUGHES *et al.*, 1979 (equivalent to *Stellatopollis hughesii* Penny, 1986) in the reference succession of the Weald-Wessex Sub-basins (HUGHES, 1994); 5 = percentage of the pollen of angiosperms in the palynological assemblage of the English reference sections; 6 = proportion between "holosteans" and teleosts. The stratigraphic distribution of the studied sediments is restricted to the MCT phases 3 and 4 (grey area), middle Barremian to earliest Aptian in age.

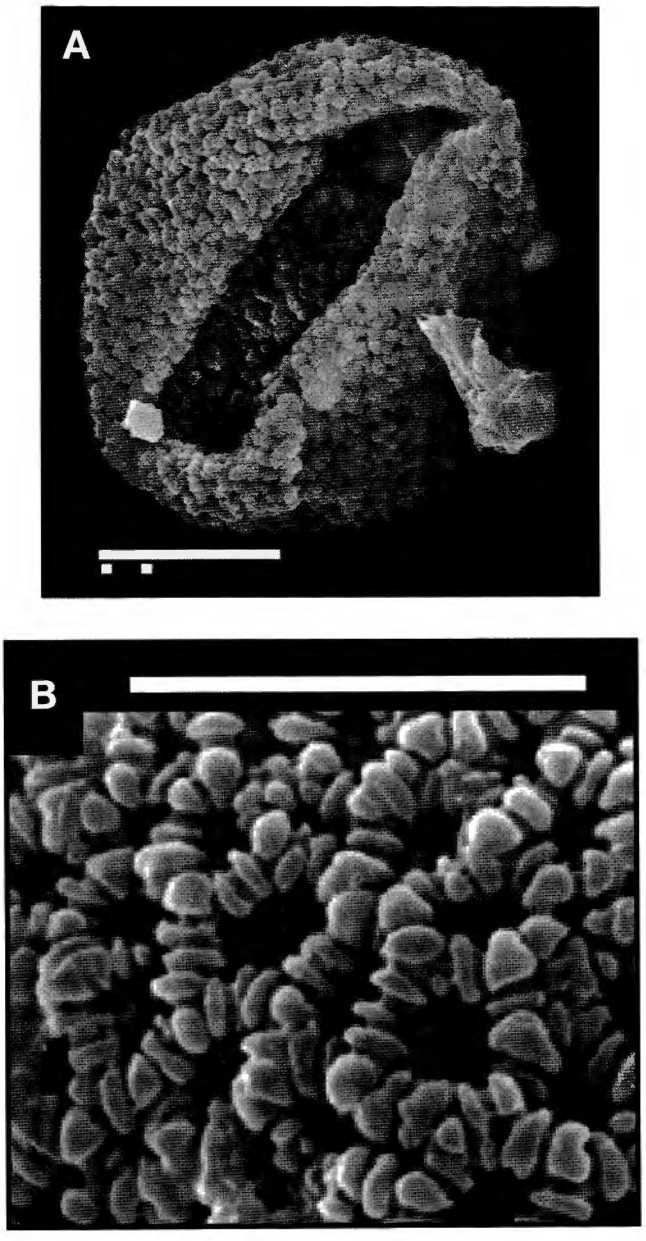

Fig. 4 — (A) Scanning electron microscope micrograph of the biorecord Superret-*croton* (equivalent to *Stellatopollis hughesii* PENNY, 1986), sample BER 7, stub n°1, scale bar = 10 µm. (IRSNB MPal P103).
(B) Scanning electron microscope micrograph of a detailed view of the crotonoid sculpture of the same pollen grain as in (A), sample BER 7, stub n° 1, scale bar = 5 µm.

HAILWOOD (1988) used magnetostratigraphy to constrain the position of the reversal, magnetochron zero (M0r). This has later been defined as the best method with which to define the Barremian/Aptian boundary, about 125 ± 1 Ma (GRADSTEIN *et al.* 2004). Following KERTH & HAILWOOD (1988) and HUGHES (1994), the M0r is located within the MCT phase 4 (Fig. 3). Therefore the upper part of the MCT 4 phase should be earliest Aptian in age.

Conclusions

The presence of the angiosperm pollen biorecord Superret-*croton* (equivalent to *Stellatopollis hughesii* PENNY, 1986) suggests a middle Barremian to earliest Aptian age for the Wealden facies sediments (and enclosed dinosaur fossils) at 322 metres depth in the "puits naturel de Bernissart". This work confirms the relevance of studying the pollen of angiosperms for dating the vertebrate fossil content in Cretaceous continental sediments. This dating could be used to confirm our understanding of the evolution in the Suborder Ornithopoda. It finally suggests that new studies on historical material could be of great interest.

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