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Early cretaceous flora from Vale Painho (Lusitanian basin, western Portugal): An integrated palynological and mesofossil study

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ABSTRACT

Mesofossil and palynomorphs of probable Berriasian age is described from Cretaceous sediments exposed in the Bombarral formation near the village of Juncal in the Estremadura region (western Portugal). Both the palynoflora and mesofossil flora are poor in species diversity and in number of specimens. The palynological assemblage is dominated by pteridophytes and gymnosperms. The mesofossil flora is dominated by conifer seeds and seeds assigned to the Bennettitales–Erdtmanithecales–Gnetales group. The associations indicate the presence of a coniferous forest dominated by Cheirolepidiaceae with a grown cover and understory vegetation of ferns and other pteridophytes as well as members of the BEG group. The fossil floras indicate a warm, seasonally dry climate. The local and regional sedimentological data also point to a seasonal climate with a prolonged dry season. The vegetational and environmental signal from the Portuguese flora is in accordance with that of other, contemporaneous floras of northern Europe (southern England, Bornholm/Denmark and Germany).

1. Introduction

A major change in terrestrial life took place during the Cretaceous period with the dramatic radiation of angiosperms (flowering plants) and the decline of many seed plant groups that characterised the Jurassic vegetation.

The first scattered records of angiosperms are from the Valanginian–Hauterivian, but flowering plants were already diverse by the mid-Early Cretaceous (Friis et al., 2010).

Many Portuguese mesofossil floras with three-dimensionally preserved floral structures, palynological assemblages with angiosperm pollen and macrofossil floras with angiosperm leaf remains have provided important information of this critical time interval, covering particularly events from the Barremian–Aptian and onwards (Friis et al., 1994, 1997, 1999, 2000, 2001, 2004, 2006, 2010). Information on the earliest Cretaceous vegetation in Portugal prior to angiosperm diversification come mainly from macrofossil floras and pollen (Groot and Groot, 1962; Heer, 1881; Leereveld et al., 1989; Pais and Reyre, 1981; Romariz, 1946; Saporta, 1894; Teixeira, 1948, 1950, 1952; Trincão, 1986, 1990), while mesofossil floras including information on reproductive organs are much more rare and there are only few studies dedicated to understand the pre-angiosperm vegetations in Portugal.

In this paper we describe a new plant assemblage from the earliest Cretaceous of Portugal based on both mesofossils and palynomorphs. The fossils are from the Vale Painho clay pit complex close to the Juncal village in western Portugal that is probably of Berriasian age. The palynological and mesofossil assemblages document a vegetation dominated by gymnosperms (mainly conifers) and ferns and strongly suggest warm and dry environmental conditions.

2. Material and methods

2.1. Sampling and preparation

The palynomorphs and plant mesofossils described here were extracted from five sediment samples (57, 58, 59, 60 and 61) collected by M.M. Mendes and J.L. Dinis in the Vale Painho clay pit complex (Figs. 1 and 2) near the village of Juncal (39° 35′ 27.4″ N; 08° 54′ 09.2″ W) in the Estremadura region, western Portugal. The sediments belong to the uppermost part of the informal Bombarral formation of earliest Cretaceous age (see Sections 2.2. and 2.3) previously assigned to the "Grés superiores com vegetais e dinossáurios" (França and Zbyszewski, 1963).

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Fig. 1. Vale Painho clay pit complex photograph showing the studied area. The arrow indicates the dark-grey mudstone sampled level.

Mesofossil were extracted from bulk samples of ca. 64 kg that were first air-dried in the laboratory, disaggregated in water and sieved over a 125 μm mesh sieve using a hand shower. The plant fossils captured on the sieve were then treated with hydrofluoric (40% HF) and hydrochloric (10% HCl) acids, thoroughly rinsed in water and dried in air. The fossils were preliminary sorted and observed under a Wild M8 Heerbrugg stereomicroscope. Specimens selected for more detailed study were mounted on polished aluminium stubs and sputter coated with gold for 60 s and examined using a Hitachi Field S-4300 scanning electron microscope (FE-SEM) at 2 kV, in the Swedish Museum of Natural History, Stockholm.

Palynomorphs were extracted from sediment samples of ca. 50 g following standard palynological techniques (Traverse, 2007) using concentrated HCl and HF to dissolve carbonates and silicates, and concentrated HNO_3 for oxidation. Organic and mineral material was separated using heavy liquid ($ZnCl_2$). Palynomorphs were generally poorly preserved, rare and of low species diversity.

For light microscopy (LM) studies five glycerine jelly microscope slides were prepared for each sample. Due to the low abundance and diversity of palynomorphs all specimens in each slide were counted for recording species diversity and the relative occurrence of the major systematic groups. LM images were taken with a Nikon Coolpix 5400 digital camera on a Nikon Eclipse E600 microscope using 60× and 100× objectives and the position of the specimens recorded using an England Finder.

For more detailed morphological analysis scanning electron microscopy (SEM) studies, a drop of water with suspended palynomorphs was pipetted to a polished aluminium stubs covered with double stick carbon tape, air dried, coated with gold for 60 s and studied using a Hitachi S-3700N scanning electron microscope at 5 kV, in the HERCULES Laboratory ("Cultural Heritage, Study and Safeguard") at the University of Évora, Portugal. SEM coordinates were recorded for all figured specimens.

SEM-micrographs were improved using Photoshop software to enhance contrast and remove stain from the background.

All specimens, slides and SEM stubs use in this study are deposited in the Earth Sciences Department, Technology and Sciences College, New University of Lisbon, Portugal.

2.2. Composition, architecture and depositional environment of the Vale Painho outcrop

About 50 m of the Bombarral formation outcrop in the Vale Painho clay pit below the unconformity at the base of the Figueira da Foz Formation (Fig. 2), with an attitude of N40W, 15 W express strike and dip. The pit is about 250 m along-dip and 200 m along-strike. In the pit the Bombarral formation is composed of alternating metre thick bodies of conglomeratic sandstones, channel deposits and lutitic and fine sandstone bodies representing overbank and floodplain sediments. The dominant channel facies are white cross-bedded medium to coarse arkosic sandstone to conglomerates and conglomeratic pavements (lags) with a maximum particle size up to about 8 cm, interpreted as channel-infill, bars and channel bed forms of a braided fluvial system. Palaeocurrents from cross-beds range from north to east, occasionally showing western azimuths, but overall they point to an average provenance from the NE quadrant. Scattered lignified and pyritized wood fragments, several centimetres in diametres, occur within the sandstone. The floodplain deposits are mainly massive red or grey mottled mudstones intercalated with lenses and ondulated thin bodies of fine to medium micaceous sandstones. We preliminarily interpreted these horizons as crevasse splays and levees. Some levels near the top of the thickest bodies of overbank fines show scattered calcite or even horizons of concretions we interpret preliminarily as nodular calcrete palaeosols. Both channel and overbank facies have frequent Fe-oxide and hydroxide crusts. The plant bearing samples were collected in exposures of dark-grey lenses of organic-rich mudstone to fine sandstone in the upper part of the Bombarral formation. These lenses are 2 to 20 m wide and up to 1 m thick, associated with fine to medium low-angle trough cross-bedded sandstone; the organic debris may form alternating horizontal or low-angle laminae, or may even be the dominant component of horizons up to 70 cm thick. The sets of low-angle cross-bedded sandstone are possibly crevasse delta lobes preserved in depressions. The horizontal laminated and more organic-rich bodies are interpreted as infill of channels, which were abandoned by avulsion events and acted as ponds where oxygen depleted slack water allowed the