



PALYNOLOGICAL RESPONSE TO THE UPPER MAASTRICHTIAN CLIMATIC CHANGES OF THE TREMP FORMATION (NE SPAIN)

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ABSTRACT

The Tremp Formation is one of the few records of continental deposits associated with the Cretaceous/Paleogene boundary in Europe. It outcrops in the northeast of the Iberian Peninsula and has been extensively studied mainly for its vertebrate fossil assemblages, as well as macroflora and microflora, which provide valuable information to understand the ecosystems prior to the biological crisis that will end the “age of dinosaurs”. In the present work, the results of the palynological analyses of two Upper Maastrichtian sites are shown. In addition to corroborating previous dating of the area, a change in the floras has been detected, which could be associated with the last Maastrichtian global warming and subsequent cooling. However, new studies should be carried out to corroborate this hypothesis.

Keywords: Paleopalinología, Paleoecología, Límite Cretácico-Paleógeno, Pirineos, Cuenca de Tremp.

1. INTRODUCTION

The biotic crisis associated to the K-Pg boundary is one of the most studied and debated subjects by the paleontological scientific community. Despite the disappearance of 70% of living faunal species (Jablonski, 1994), including notable losses such as non-avian dinosaurs, pterosaurs and several crocodylomorphs, the flora seems to accuse the crisis in a different scale. Cascales-Miñana & Cleal (2014) noted that vascular plants did not decrease their diversity at the family level. However, high-resolution palynological studies

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indicate a 30% decline in the biodiversity of the North America microfloral assemblages and 15% in the New Zealand ones (Vadja & Bercovici, 2014).

Only a few areas contain pre-impact continental deposits close to the K-Pg boundary globally. In Europe, the Tremp Formation (Maastrichtian-Danian) outcrops in the NE of the Iberian Peninsula. Remarkable vertebrate paleontological findings have been made in this formation, and it also contains some of the most modern Mesozoic paleontological continental sites in Europe (Pérez-Pueyo, 2023 and references there in).

In the palynological field, thirteen studies have been carried out in the area since the seventies to characterize the microflora before and after the K-Pg boundary (Martínez de Espronceda *et al.*, 2024 and references therein).

2. GEOGRAPHIC AND GEOLOGICAL CONTEXT

The study focused on two sites in the northwestern sector of the Tremp Basin, in the South-Central Pyrenees (Huesca, Aragón, NE Spain). The sites studied are located in two informal lithostratigraphic units within the Tremp Fm; Camino Fornons 3 (CF3) is at the top of the basal 'Grey Unit', mainly composed of mudstones and marly mudstones with intercalations of fine-grained sandstones and sandy limestones, interpreted as a lagoonal system. Meanwhile, Altero Negro 1 (AN1) is at the top of the overlying 'Lower Red Unit', composed mainly of continental mudstones and sandstones and interpreted as an alluvial floodplain (Villalba-Breva *et al.*, 2012). Both units have been dated within the polarity chron C29r, late Maastrichtian, for this area of the basin (Puértolas-Pascual *et al.*, 2018).

3. RESULTS

A total of six palynological samples were collected, three per site. After the palynological standard treatment consisting of HCl-HF-HCl, four samples were productive, two per site.

The obtained palynological assemblages showed differences in abundance, composition, and diversity. In CF3 56 taxa were identified with a relative dominance of angiosperm pollen, outstanding the Normapolles group, as well as pteridophyte spores. In the case of AN1, the relative abundance and diversity were lower; 49 taxa were identified. The assemblage also showed relative abundance of angiosperm pollen and pteridophyte spores, although in AN1, the gymnosperm pollen grains were significantly abundant.

4. DISCUSSION

The western region of the Tremp Formation has been previously dated using different techniques (magnetostratigraphy, biostratigraphy with charophytes and palynology) providing a late Maastrichtian (C29r) age for the

'Grey Unit' and the 'Lower Red Unit' in this sector (Puértolas-Pascual *et al.*, 2018; Pérez-Pueyo, 2023; Martínez de Espronceda *et al.*, 2024). In this work, the palynological assemblage from CF3 and AN1 confirm a late Maastrichtian age for both units.

The palynological dating for CF3 and AN1 sites was carried out based on the K-Pg key taxa suggested for the Ibero-Armorican region (Martínez de Espronceda *et al.*, 2024). Therefore, the presence of *Subtriporopollenites microconstas* constrains the age to the Maastrichtian, and according to the First Occurrences of *Pandaniidites texus*, *Rugulitriporites pflugii* and *Bacumorphomonocolpites* sp. and Last Occurrences of *Lusatisporis dettmannae*, *Trudopollis granulosis* and *Aquilapollenites* sp. a late Maastrichtian age is confirmed for both units.

The plant community of CF3, according to the dominant palynomorphs found in the assemblage, can be interpreted as a seaside forest composed of Juglandaceae and Myricaceae trees/shrubs, with an understory dominated by Liliaceae herbs and the presence of Cyatheaceae ferns and representatives of the family Selaginellaceae. The paleoenvironment of the area seems to be transitional with continental and marine influence. The presence of freshwater algae (*Chomotriletes fragilis*) together with marine palynomorphs, such as foraminifera test linings, supports a transitional environment with marine influence. This condition agrees with the previous 'Grey Unit' interpretation as a lagoonal system. In the CF3 assemblage, Gondwanan influence has been detected (e.g., *Bacumorphomonocolpites*). It has been already observed in the upper Maastrichtian of the Iberian Peninsula and the Netherlands (Martínez de Espronceda *et al.*, 2024 and references therein).

The AN1 plant community shows certain similarities with the CF3 site. Juglandaceae and Myricaceae trees/shrubs and pteridophytes, along with Liliaceae herbs are present, but the gymnosperm families Araucariaceae and Sciadopityaceae show a mixed forest with perennial and deciduous species. Another difference is the lack of Gondwanan influence, which seems to be replaced by boreal influence due to the record of the taxa *Aquilapollenites* and *Sciadopityspollenites*. The first one seems to be restricted to the *Aquilapollenites* palynoprovince during the Late Cretaceous, which has been previously reported from the upper Maastrichtian of the Iberian Peninsula (Mayr *et al.*, 1999) and southern regions such as Gabon or Senegal (Belsky *et al.*, 1965; Jardiné & Magloire, 1965). Additionally, *Sciadopityspollenites* is a taxon typical of high latitudes, where its relative abundance is higher.

The Gondwanan and boreal taxa occurrences in the sites may suggest changes related to the climate and the paleoenvironment that affected the flora. During the Maastrichtian, several global climate changes were detected. The last climate warming happened between the last 300ka to 150ka before the asteroid impact. It was followed by climate cooling (Stüben *et al.*, 2003; Gilabert *et al.*, 2021). Based on the assemblages described in both sites, it is possible that CF3 could be associated with the maximum Maastrichtian climate, and the AN1 assemblage may correspond to a cooler

period just after the last maximum. This is consistent with the stratigraphical location of both sites, where the CF3 is below the AN1 site.

Nevertheless, CF3 and AN1 are located in two different lithostratigraphic units representing two distinct paleoenvironments. The 'Grey Unit' has been interpreted as a transitional one, with marine and continental influence, meanwhile AN1 is located at the top of the 'Lower Red Unit', interpreted as a continental unit, representing an alluvial plain. This change may have influenced the paleofloras in the area changing the coastal forest described in CF3 into a mixed forest of AN1 due to the marine regression and the environment change associated. However, further research should be done to confirm one of these hypotheses.

5. CONCLUSIONS

The palynological assemblages from lithostratigraphic units CF3 and AN1 suggest a late Maastrichtian age, reinforcing the previous biostratigraphic and magnetostratigraphic dating. The microfloral assemblage of CF3 shows a plant community dominated by Jungladaceae/Myricaceae trees and shrubs and Liliaceae herbs with Gondwanan influence. In AN1, the plant community has similarities with CF3, but boreal influence was detected along with the abundance of gymnosperm pollen grains.

The microfloral differences between both sites may be suggesting a possible climate change that affected the plant communities. In CF3, the floral assemblage shows a temperate/subtropical humid coastal forest; meanwhile AN1 shows a temperate mixed forest. The relative high presence of boreal pollen in AN1 may be showing, a cooler environment in comparison to CF3 assemblage. However, both sites are located in different lithostratigraphic units interpreted as two different paleoenvironments which means that the floristic changes observed can be also related to an environmental change, possibly linked to the end of the Cretaceous marine regression. Nevertheless, further research should be done to confirm or refute these hypotheses.

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ZUBÍA

42



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