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Les kystes de dinoflagelles et palynofacies de la transition Maastrichtien–Danien du stratotype El kef (Tunisie)

Dinoflagellates cysts and palynofacies from Maastrichtian–Danian transition at the stratotye El kef (Tunisia)

Info.suppl.

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RÉSUMÉ

L'étude palynologique des dépôts de la limite Crétacé–Paléogène (K–Pg) du stratotype El kef, Tunisie, a montré une richesse exceptionnelle en palynomorphes. Les kystes de dinoflagellés (dinokystes) sont abondants, diversifiés et bien conservés. La limite K–Pg se trouve juste après la dernière apparition des espèces crétacées *Dinogymnium cretaceum*, *Dinogymnium acuminatum* et *Pterodinium cretaceum*, et directement au-dessous de la première apparition des espèces marqueurs du Danien basal, telles que *Damassadinium californicum*, *Membranilarnacia*? *tenella*, *Senoniasphaera inornata*, *Carpatella cornuta*, *Eisenackia circumtabulata* et *Lanterosphaeridium reinhardtii*. L'âge attribué à ces niveaux à l'aide des kystes de dinoflagellés est en accord avec celui déterminé à l'aide des foraminifères planctoniques. L'étude du palynofaciès a montré la présence d'une matière organique, dominée par les palynomorphes marins, principalement les kystes de dinoflagellés. Les palynomorphes continentaux (sporomorphes) et la matière organique amorphe (MOA) sont également présents dans tous les échantillons. Le microplancton est dominé par les péridinoïdes, avec un enrichissement progressif au Danien, notamment en ce qui concerne le groupe de *Senegalinium*. Dans ces dépôts, le contenu en carbone organique total (COT) est généralement inférieur à 0,6 % en poids. Les analyses de la pyrolyse Rock–Eval et l'étude de palynofaciès montrent une matière organique immature de type II et III avec un indice d'altération thermique (TAI) faible.

Keywords:
Cretaceous–Paleogene boundary
Dinoflagellate cysts
Palynofacies
Stratotype El kef

ABSTRACT

A palynological study of the Cretaceous–Paleogene (K–Pg) boundary deposits at the stratotype El kef, Tunisia, showed an exceptional richness of palynomorphs. Dinoflagellate cysts (dinocysts) are abundant, diversified and well preserved. The K–Pg boundary lies right after the last appearance of the Cretaceous species, *Dinogymnium cretaceum*, *Dinogymnium acuminatum* and *Pterodinium cretaceum*, and directly below the first appearance of

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the species markers of the basal Danian, such as *Damassadinium californicum, Membranilarnacia*? *tenella, Senoniasphaera inornata, Carpatella cornuta, Eisenackia circumtabulata* and *Lanternosphaeridium reinhardtii*. The age determined for these levels based on dinocysts is in agreement with that determined using planktonic foraminifera. The palynofacies study showed an organic matter dominated by marine palynomorphs, essentially dinoflagellate cysts, the sporomorphs are rare. Continental palynomorphs (Sporomorphs) and Amorphous Organic Matter (AOM) are present in all samples. The microplankton is dominated by peridinoid dinocysts with a progressive enrichment at Danian, mainly the *Senegalinium* group. The Total Organic Carbon (TOC) content is generally less than 0.6 wt %. The TOC, Rock–Eval pyrolysis and palynofacies analyses indicate that the El Haria Formation presents immature organic matter of types II and III and a low Thermal Alteration Index (TAI).

Abridged English version

The present work aims to study dinoflagellate cyst biostratigraphy of the Maastrictian–Danian transition at the stratotype El kef, Tunisia, (Figs. 1 and 2) and to interpret the palynofacies analysis and evaluation of organic matter by geochemical analysis that combines Rock-Eval pyrolysis and TOC. This palynological study, revealed the presence of marine organic-walled microfossil assemblages consisting of well preserved dinocysts, representing 90 % of total palynomorphs. Spores, pollen, acritarchs and foraminiferal linings are rare.

The biostratigraphic interpretation, based on dinocyst events, suggests continuous sedimentation in the studied interval of the section and shows that the K–Pg boundary lies just above the Uppermost Maastrichtian global marker acme of *Manumiella seelandica* and the last appearance of few Cretaceous taxa such as *Dinogymnium* spp. and *Pterodinium cretaceum*, and directly below the first appearance of the basal Danian markers *Damassadinium californicum*, *Membranilarnacia*? *tenella*, *Senoniasphaera inornata, Lanternosphaeridium reinhardtii* and *Carpatella cornuta*. This boundary based on dinocyst biostratigraphy coincides with the K–Pg boundary based on lithostratigraphy and planktic foraminiferal (Gallala, 2010). These bio- events confirm localization of the K–Pg boundary between the two Kef 24 and Ka 2 levels, at the base of the red clay, as defined in the El kef GSSP (Molina et al., 2006). The age determination is based on the comparison with the dinocyst assemblages described in the Maastrichtian–Danian transition of the Northern Hemisphere, including Mediterranean sections in Tunisia (Brinkhuis and Zachariasse, 1988; Brinkhuis et al., 1998; Dupuis et al., 2001; M'Hamdi, 2014; M'Hamdi et al., 2013), Spain (Brinkhuis et al., 1998; De Coninck and Smit, 1982), Morocco (Guédé et al., 2014; Slimani and Toufiq, 2013; Slimani et al., 2010; Soncini, 1990), the Middle East (Eshet et al., 1992) and also in other areas of northern Europe in Denmark (Hansen, 1977), The Netherlands (Brinkhuis and Schiøler, 1996), Belgium (Slimani, 2001; Slimani et al., 2011) and Germany (Kuhn and Kirsch, 1992).

Quantitative and qualitative analysis of dinocysts at El kef section, indicate that no extinction occurred in dinoflagellate cysts unlike the mass extinction recorded in planktonic foraminifera assemblages (Gallala, 2010; Zaaghbib-Turki et al., 2000, 2001), but show remarkable changes in the relative abundances of species or groups of morphologically related species (*Areoligera* spp., *Manumiella seelandica*, *Spiniferites* spp. and *Senegalinium* spp.). The observed dinocyst assemblage is dominated by species of *Cerodinium*, *Lejeunecysta*, *Senegalinium*, *Andalusiella*, *Phelodinium* that characterize the Malloy suite (Lentin and Williams, 1980), and thus confirms deposition under a tropical to subtropical province for the studied interval of El kef section.

The palynofacies study of the Cretaceous–Paleogene transition deposits from the El Haria Formation at the El kef section, revealed the presence of an organic matter dominated by marine palynomorphs; continental palynomorphs (Sporomorphs) and Amorphous Organic Matter (AOM) are also present. The palynomorphs are dominated by dinoflagellate cysts, which are diversified and well-preserved, however the sporomorphs are rare.

The palynofacies distribution is evaluated based on a qualitative and quantitative analyses of dispersed organic constituents. In the AOM- Phytoclast- Palynomorph ternary diagrams of Tyson (1993), the different proportions of the components of this organic matter indicate a palynofacies dominated by abundant palynomorphs 65 % (Fig. 4B). Projection in the Palynofacies diagram of Roncaglia and Kuijpers (2006) shows that different organic matter components are dominated by marine-derived organic matter, such as dinoflagellate cysts, acritarchs and foraminiferal test linings (Fig. 4A). The geochemical data from the El kef section allow a characterization of the organic matter (Table 1). The kerogen has low TOC contents (<0.6 wt.%) and is predominantly characterized by marine organic matter and marine palynomorphs, preserved in a marine environment. The results (low values of TOC, S2 and HI) show that the El Haria Formation at El kef section contains kerogens type II and III (Fig. 5). The maturity indicators (T_{max}) suggest an immature stage of organic matter.

1. Introduction

La limite Crétacé–Paléogène (K–Pg), représente une des cinq crises biologiques majeures, ayant affecté plusieurs groupes biologiques (Berggren, 1962a, 1962b). Elle est marquée par une couche rouge d'épaisseur millimétrique, riche en cristaux de spinelle nickélifère et de quartz choqués là où la teneur en iridium (Ir) est élevée et dépourvue de fossiles (Boersma et Premoli Silva, 1983 ; Canudo et al.,