Ichnological analysis of the Cretaceous–Palaeogene boundary interval in the Caravaca and Agost sections, southern Spain

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Ichnological analysis of the K–Pg boundary at Caravaca brings new important data for the interpretation of the boundary event. The uppermost Maastrichtian marls below the boundary contain the dark-coloured trace fossils *Chondrites targionii, Planolites, Thalassinoides, Zoophycos*, and *Alcyonidiopsis*, which are filled with sediment from the dark boundary layer. The trace fossil taxa in the upper Maastrichtian and lower Danian marls are generally the same, yet much more poorly preserved in the latter. The dark-coloured trace fossils penetrate from two bioturbated horizons in the dark boundary layer, separated by two horizons with primary lamination. The ichnofauna rapidly recovered after the K–Pg event following deposition of the lower, parallel-laminated bed, 14 mm thick, that occurs in the dark boundary layer above the K–Pg boundary. In general, there is no evidence of a severe macroinfaunal crisis among tracemakers at the K–Pg boundary. *Zoophycos* is the deepest ichnofossil, penetrating as far as 90 cm below the K–Pg boundary, probably in stiff or partly firm substrate, which was dewatered to some extent during the slow accumulation of the Danian dark boundary layer. *Chondrites targionii* penetrates 35 cm and *Thalassinoides* 20 cm below the boundary. The firmness probably prevented the *Chondrites* tracemaker from deeper burrowing. The Maastrichtian sediments may be contaminated with Danian microfossils due to bioturbation (Rodríguez-Tovar & Uchman, 2006).

The rusty layer at the base of the dark boundary layer, usually related to the K–Pg boundary impact, is traditionally considered as undisturbed. However, at the Caravaca section the rusty boundary layer is cross-cut vertically by *Zoophycos* and *Chondrites*. It is also penetrated laterally by *Chondrites*, revealing an important colonization of the substrate. Colonization of unfavorable substrates by *Zoophycos* and *Chondrites* tracemakers, as that represented by the rusty boundary layer, was possible because of constructing of open, probably of actively ventilated burrows that facilitate colonization of sediments poor in oxygen and food. Significant bioturbational disturbance of the rusty layer can cause vertical and horizontal redistribution of the components related to the K–Pg boundary impact and, in consequence, to induce erroneous interpretations (Rodríguez-Tovar & Uchman, 2008).

In the Agost section, *Chondrites* ?*targionii*, *Zoophycos*, *Planolites*, *Thalassinoides*, *Alcyonidiopsis longobardiae*, and *Diplocraterion* ?*parallelum* have been identified in the uppermost Maastrichtian below the K-Pg boundary (Rodríguez-Tovar & Uchman, 2004a). They show endobenthic tiering, being *Chondrites* and *Zoophycos* the deepest burrows. The trace fossil assemblage represent vertical partitioning of a singled multi-tiered community under steady-stable conditions in well-oxygenated water bottom, reflecting gradual changes deep into the sediment, with decreasing oxygen pore water and benthic food, and increasing substrate consistency, or a sequential colonisation and community replacement, reflecting the work of two successive communities. In the latter scenario, *Planolites*, *Alcyonidiopsis* and *Thalassinoides*, was produced in a shallow, oxygenated soft substrate by vagile or semi-vagile burrowers. This community was replaced by deeply burrowing stationary deposit-feeding or farming organisms that produced *Chondrites*, and by chemichnial ?sipunculoid worm that produced *Zoophycos*. This replacement is related to decreasing oxygen content and benthic food availability (Rodríguez-Tovar & Uchman, 2004b).

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