Ichnological record of macrobenthic community changes across the Paleocene-Eocene Thermal Maximum in the Zumaia section, northern Spain

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The Zumaia section on the Biscay Bay coast can be considered one of the most complete, continuous and expanded sections of the Paleocene in open-marine facies in western Europe and the Mediterranean, where the Paleocene-Eocene boundary (P/E) is precisely determined at the base of a few metres thick package of red marls. The boundary interval contains trace fossils that were significantly affected by the environmental changes related to the Paleocene-Eocene Thermal Maximum (PETM). High-resolution ichnological analysis point to well marked different ichnological features before, during, and after the event.

A well developed normal, tiered burrowing community (larger and smaller *Chondrites*, *Planolites*, *Scolicia*, *Thalassinoides*, *Zoophycos*, and punctually *Avetoichnus*), is present in marls with glauconite, and in turbiditic sandstones and limestones, below the PETM, indicating oxic conditions and normal benthic food availability. Towards the P/E, ichnodiversity and ichnofossils abundance decrease, indicating progressive deterioration of the environmental conditions for macrobenthic community.

In red marls with green spots deposited during the PETM the trace fossils disappeared rapidly. Nevertheless, the sediment is bioturbated, mottled ichnofabrics, but without trace fossils preserved. This can reflect the global increase in temperature, and the concentration of benthic food in the very shallow water saturated surface sediment layer, in which preservation of trace fossils was impossible due to low sediment cohesion (soupground). An about 20 cm thick interval with primary horizontal lamination and the absence of bioturbation is present in the lower part of the red marls, probably indicating drastic oligotrophy conditions during climax of the PETM, and local depletion of oxygen within the sediments, although probably not true anoxia. The environmental perturbation significantly affected the whole benthic habitat, as shown by the correspondence with the main phase of the benthic foraminiferal extinction.

After the PETM, in light grey marls and marlstones, the normal, tiered burrowing community (mainly *Planolites, Thalassinoides, and Zoophycos*) recovered gradually and slowly, in a delayed return to pre-PETM environmental conditions.

The changes in the trace fossil assemblage across the PETM document the impact of this event on the macrobenthic community, in response to the global warming and related environmental variations, and the similarities and differences in the response of micro- macrobenthic communities to global phenomena. Thus, ichnological analysis reveals as a very useful additional tool to understanding atmosphere-ocean dynamic during PETM and a potential way in future climate research.