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Mercury anomalies in Palaeocene-Eocene Thermal Maximum (PETM) successions of Pyrenean peripheral basins: new evidence of a plausible link between volcanic emissions from the North Atlantic large igneous province and the PETM

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The Palaeogene represents the last “greenhouse” period characterized by high atmospheric CO₂ concentrations and warm surface temperatures. This long-term climatic state was punctuated by several transient hyperthermal events. These events are recorded primarily by prominent negative carbon isotope excursions (NCIE) in both carbonates and organic matter of sedimentary successions. The largest hyperthermal of the Palaeogene, the Palaeocene-Eocene Thermal Maximum (PETM), is associated with a 5-8° rise in global temperature, ocean acidification and a global biotic perturbation. The PETM is thus often seen as a geological analogue for future greenhouse-gas-driven global warming. The source of the ¹³C-depleted carbon for the NCIE and whether it was released in one or numerous events however remains controversial. Numerous carbon sources have been suggested, either in concert or individually to explain the onset and the duration of the NCIE. These include magmatic as well as thermogenic release of CO₂ associated with large scale magmatism. Over the last decade, mercury (Hg) found in marine and continental sedimentary succession has emerged as a potential proxy of past volcanic emissions, allowing to trace the relationship between the emplacement of Large Igneous Provinces (LIP) and periods of warming, mass extinctions, and biotic disruptions.

Although the PETM is widely recorded in pelagic and hemipelagic settings, its record in shallow-water and continental successions remains scarce due to frequent hiatuses and unconformities in such environments and a lack of enough biostratigraphic constraints. However, the high sedimentation rate, which may characterize shallow water settings, compared to deeper marine environments, may potentially preserve expanded NCIE successions to better understand the

nature and causes of the PETM

In this study, we present the first synthetic high-resolution mercury and stable isotopic records of three shallow-water and continental successions from highly subsident peripheral basins North (Lussagnet) and South (Serraduy and Esplugafreda) of the Pyrenean orogen across the PETM. In those sections, our results show two important negative carbon isotope excursions in the bulk-rock carbonates. Based on biostratigraphy and similarity of shape and amplitude of the isotopic excursions with global records, the largest NCIE is interpreted as the NCIE associated with the PETM. This excursion is immediately preceded by another NCIE, second largest in amplitude in our record, and that we interpret as the Pre-Onset Excursion (POE), found in few other profiles worldwide. The occurrence of the POE suggests a first episode of ^{13}C -depleted carbon release before the onset of the PETM. These various NCIE are associated with important mercury anomalies, even when normalized to total organic content. This suggests that pulses of magmatism, probably associated to the emplacement of the North Atlantic Igneous Province (NAIP), contributed to the onset and to the long duration of the PETM.

Our work confirms that hyperthermal events of the Palaeogene can be well recorded in shallow water and continental successions and can be used as powerful stratigraphic tools for these depositional environments, in addition to providing information on the climatic perturbations associated with the PETM.

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