Causes, consequences of global climate warming that took place 56 million years ago studied

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This image shows continental sediments in the Esplugafreda ravine, a small tributary of the Noguera Ribagorzana river, in the extreme west of the province of Lleida and close to the village of Aren (Huesca). Credit: UPV/EHU-University of the Basque Country

The growing and justified concern about the current global warming process has kindled the interest of the scientific community in geological records as an archive of crucial information to understand the physical and ecological effects of ancient climate changes. A study by the UPV/EHU's Palaeogene Study Group deals with the behaviour of the sea level during the Palaeocene–Eocene Thermal Maximum (PETM) 56 million years ago and has ruled out any connection. The study has been published in the journal *Palaeogeography, Palaeoclimatology, Palaeoecology*.

"The fall in sea level did not unleash the emission of greenhouse gases during the Palaeocene–Eocene Thermal Maximum (PETM)," pointed out Victoriano Pujalte, lecturer in the UPV/EHU's Department of Stratigraphy and Palaeontology, and lead researcher of the study.

The Palaeocene–Eocene Thermal Maximum (PETM) was a brief interval (in geological terms, it "only" lasted about 200,000 years) of extremely high temperatures that took place 56 million years ago as a result of a massive emission of greenhouse gases into the atmosphere. The global temperature increase is reckoned to have been between 5º C and 9º C. It was recorded in geological successions worldwide and was responsible for a great ecological impact: the most striking from an anthropological point of view was its impact on mammals, but it also affected other organisms, including foraminifera and nannofossils (marine microorganisms that are at the base of the trophic chain) and plants.

However, what actually caused this warming remains a controversial issue. The most widely accepted hypothesis suggests that it was due to the destabilising of methane hydrates that remained frozen on ocean floors. "Some authors, like Higgins and Schrag (2006), for example, proposed that a fall in sea level could have caused or co-contributed towards the unleashing of the emission of methane or CO2," pointed out

Victoriano Pujalte, lecturer in the UPV/EHU's Department of Stratigraphy and Palaeontology, and lead researcher in the study. According to this hypothesis, "the marine sediments that were submerged in the sea were exposed when the sea level fell, and were responsible for the CO2 emissions," he added. That is what, to a certain extent, prompted this study. Others not only reject that possibility but also the fall in sea level itself. "We set out to try and establish the behaviour of the sea level during that time interval, the PETM," said Pujalte.

There is no cause-effect relationship

The studies were carried out mainly in the Pyrenees between Huesca and Lérida, specifically in the Tremp-Graus Basin, and also in Zumaia (Gipuzkoa, Basque Country). The Palaeocene-Eocene rocks have outcropped extensively in both areas, in other words, exposed on the surface, and they represent a whole range of ancient atmospheres, both continental and marine. "They provide a unique opportunity to explore the effects of changes in sea level and to analyse their effects," added Pujalte.

The most useful indicators are the stable oxygen and carbon isotopes. The oxygen ones provide information on palaeotemperatures, but any sign of them can only be retrieved in deep-sea sample cores. The carbon isotopes provide data on variations in CO2 content in the atmosphere and in the oceans, and they can also be retrieved in ancient rocks that have outcropped in above-ground plots of land. In general, the variations of both isotopes run parallel, given that an increase in the proportion of CO2 is coupled with an increase in temperature.

The results obtained indicate that the PETM was in fact preceded by a fall in sea level, the size of which is estimated to have been about 20 metres and the maximum descent of which probably occurred about 75

million years before the start of the PETM. "However, it is doubtful that the descent was the cause of the PETM, although it could have contributed towards it," pointed out Victoriano Pujalte. "They occurred at the same time, but there is no cause-effect relationship."

Furthermore, the researchers observed that the rise in the sea level continued after the PETM, when the global temperature returned to normal levels. "Its origin was not only caused, therefore, by the thermal expansion of the oceans linked to the warming," said Pujalte. "It is suggested that the most likely cause of it was the volcanic activity documented in the North Sea during the end of the Palaeocene and start of the Eocene; this activity was related to the expansion of the oceanic ridge in the North Atlantic," he concluded.

More information: V. Pujalte, B. Schmitz. J.I. Baceta. Sea-level changes across the Paleocene-Eocene interval in the Spanish Pyrenees, and their posible relationship with North Atlantic magmatism. 2014. *Palaeogeography, Palaeoclimatology, Palaeoecology* 393: 45-60 www.sciencedirect.com/science/ … ii/S0031018213004720

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