Environment and Evolution Through the Paleocene-Eocene Thermal Maximum

The Paleocene-Eocene Thermal maximum is best known for its drastic effect on the marine realm, but the following paper addresses its potential impact on terrestrial life. The PETM was an interval of unusual warmth superimposed on a larger global warming trend and occurring over a brief geological timespan. It is associated with an extinction event amongst benthic foraminifera, a global negative carbon isotope excursion that has proven useful for correlating marine and terrestrial records and the emergence of the majority of the modern mammalian orders (including the artiodactyls, perissodactyls and primates). This paper examines the terrestrial circumstances surrounding the first appearances of these mammal taxa, and speculates on how the unique environmental conditions may have shaped the earliest ungulates and primates. The PETM is now considered a turning point of sorts in the history of life, as it represents a shift from “archaic” mammals to the early forms of modern orders that may have been moderated wholly by climate change. Early Eocene mammals tended towards miniature body sizes, thought to be a response to high temperatures. Furthermore, the precise time resolution of the PETM permits paleontologists to calculate more accurate rates of mammal speciation, which helps to address some fundamental questions about evolution (like the relative predominance of the Red Queen or “Stationary” models).

I have read extensively on the PETM from the marine perspective, with the terrestrial record mentioned only as an afterthought. So, I greatly enjoyed reading about what was going on in the mammal world! I especially liked that the paper went into detail about the sequence of speciation events, to get a better handle on what traits were most advantageous, like dwarfism, and how those traits changed as the taxa became more derived. The paper’s discussion of the geographical distribution of these speciation events was interesting as well; I had never previously considered variability in the land record. Furthermore, this paper introduced me to the PETM’s usefulness for theoretical evolutionary biology; the author considers it a window for which molecular phylogeny and the fossil record can be aligned, which would be incredibly cool!

Normally, I wish authors would include more background in their papers, as even their peers in the field may not have the same knowledge of jargon or technique. However, I felt that this paper was long on background and short on the promised subject of mammalian turnover during the PETM. Perhaps this is because I work with Clay Kelly and have had multiple classes with him, but I found the detail with which Dr. Gingerich presented the basics of the PETM unnecessary. The background could have been relegated to the introductory section, with perhaps an additional paragraph explaining how the marine records were correlated to the land records. I liked that his explanation of carbon and oxygen isotopes was contained in a side “box,” and would have liked to have seen that done with some of the starting information as well. Maybe the section on the benthic foram extinction could have been taken out of the main text and put in such a box, or perhaps the methane hydrate and Milankovich hypotheses (since the cause of the PETM is not the main focus of the paper). This would have made more space for the discussion of mammal evolution.

The four figures were simple and accessible, and appropriate for the paper. Figure 1 was a great summary of North American PETM events, juxtaposing carbon and oxygen isotope records with mammalian stratigraphic ranges and the age and epoch level timescale. The perfect alignment of perissodactyl, artiodactyl and primate first occurrences with the PETM is compelling. Figure 2 was a simple map of marine and land PETM sites, and I wish it was more closely related to the text where the author describes global PETM records. Figure 3 was unnecessary, since it related to benthic forams and not the mammalian trends discussed in the abstract and main paper. Figure 4 was fascinating, as it graphically showed the concurrence of small body sizes and the PETM. It was well-connected to the text and did a better job of shoing its transience than the writing fully conveyed.