Review of "Climatic and tectonic controls on shallow marine and freshwater diatomite deposition through the Palaeogene" by Cécile Figus, Or M. Bialik, Andrey Yu. Gladenkov, Tatyana V. Oreshkina, Johan Renaudie, Pavel Smirnov, and Jakub Witkowski. (EGUSphere in review). August 23, 2024.

Reed Scherer, Northern Illinois University

General Comments:

Diatoms play a key role in global biogeochemical cycling, contributing to atmospheric oxygen levels and to CO_2 regulation through sequestration in geological deposits. Diatoms require high nutrients to bloom and accumulate, so intervals of diatom proliferation on and near continental masses typically correlate with times of rapid continental weathering and delivery to non-marine and marginal marine waterways; the latter including both epicontinental seas and along continental shelves, especially near river mouths that carry a high dissolved nutrient load but low sediment load. By contrast, deep-sea diatomite accumulation is typically dominated or augmented by upwelling of nutrients at oceanic divergence zones, driven by broad ocean circulation patterns. These may be along continental margins (e.g, California coast), or in open ocean settings (e.g., the Southern Ocean).

Figus et al. have analyzed occurrences of Paleogene diatomites around the world, based on literature surveys, seeking patterns that may relate to global climate changes in the Hothouse world. The analysis they present is based on literature surveys of terrestrial exposures. Their paper is an ambitious compilation that provides an important window into a critical interval in Cenozoic history. Their chief aim is to evaluate the hypothesis that Paleogene diatomite accumulation was driven predominantly by climate change. One notable new observation is a possible "diatomite gap" between ~46 and ~43 Ma.

There are, of course, biases and limitations of the stratigraphic record, which they acknowledge. The greatest limitation is access to material for study. On the continents, marine diatomites will only accumulate during times and in places affected by of high sea level. Access these strata is limited because they may have become deeply buried with little or no exposure, or, once exposed, these deposits are highly susceptible to erosion. Consequently, terrestrially-based Paleogene diatomites are very rare. Access to appropriate deep-sea deposits is even more challenging. Most known oceanic Paleogene diatomites were recovered by ocean drilling around the world and are not part of this paper. Some Paleogene open ocean diatomaceous deposits are found on land in some coastal areas, having been tectonically uplifted. Paleogene deep-sea sediments, accessible only through ocean drilling, may be deeply buried, increasing their susceptibility to diagenesis and also making them less accessible through high quality drilling. Moreover, Paleogene diatomites that would have accumulated in the deep sea across global oceans have already been subducted and destroyed, thus very severely limiting assessment of global Paleogene deep sea accumulation.

Specific Comments:

The authors limit their analysis to sediments both exposed on land and technically defined as diatomite, excluding diatom-bearing muds. They distinguish three categories of Paleogene diatomite: freshwater diatomites, epicontinental sea deposits (ES) and open ocean settings (OOS). Their database lists 102 terrestrially exposed diatomites used in the analysis. Of these only 17 are classified as OOS and 20 as freshwater. Thus, the bulk of their sites are classified as ES, making it the main topic. Late in the manuscript they note that " The distribution and deposition of deep-sea diatom-bearing sediments will be examined in a future article and compared with the results of this study". I'm glad to see this, but it should be acknowledged up front. Furthermore, the database is heavily weighted toward outcrops in Europe and Eurasia, with exceedingly few sites in the Southern Hemisphere and only a few in North America, central Asia and none in Africa, India, Australia or Antarctica. This is, admittedly, an inherent and unavoidable weakness in an attempt at a global assessment. Compiling global literature such as this as a challenge, rife with pitfalls, but the authors do an admirable job of seeking the big picture and to their credit, they take a conservative approach. The database excludes famous Paleogene diatomites such as Oamaru diatomite (New Zealand). Without specifically naming it, they do explain why sites like Oamaru are excluded from their database (the outcrop is no longer accessible), but Oamaru is so well-documented that I'd think it should be included.

What this reviewer finds lacking is a more explicit definition of shallow versus open ocean marine diatomites. Epicontinental seas can be extensive during times of elevated sea levels across low-lying continental masses, but what about along continental margins, which may include expansive continental shelf areas, which are by definition shallow marine? Inferences distinguishing shallow water (say, under ~100m paleo water depth, from deeper paleodepths of continental slopes and rises, which would constitute true OOS, can be drawn from analysis of the diatom assemblages. For example, the occurrence of benthic, notably epipsammic, and neritic resting spore-forming taxa would go far in establishing coastal marine (continental shelf) from true open ocean settings, but this approach is not discussed in this paper.

Many Eocene marine diatomites recovered from drilling and coring along continental margins and on submerged/subsided microcontinental masses represent deposition in shallow (or relatively shallow) marginal marine settings that may not be significantly influenced by open ocean currents, especially in narrow basins with restricted flow, such as that recovered by IODP Expedition 396 and earlier drilling in the Norwegian Sea (see Berndt et al., 2023; Planke et al., 2023; Schrader and Fenner, 1976). The cruise report from Exp. 396 notes the ecological similarity of the diatom assemblages to those of the epicontinental Russian Platform sites they include in their database, and, to a somewhat lesser extent, the Fur Formation in Denmark. These diatomites differ markedly from true deep ocean sites. Consequently, most Vøring Plateau sites should be classified as ES deposits, although recovered from an offshore continental margin that lies in relatively deep water today. Such acknowledgement or, better still, analysis, would add length to the paper, but would greatly strengthen its impact.

The authors prominently note an ES diatomite gap between 46 and 43 Ma in epicontinental seas, and an onset of diatomite accumulation in the open ocean beginning at 43.5 Ma. Some pure, likely shallow water diatomites recently recovered from the Norwegian Sea (IODP Exp. 396, sites U1571 and U1572) are dated slightly older than this noted gap (mid-Lutecian, between ~44 and ~43.5 Ma, based predominantly on dinoflagellate biostratigraphy). Some of these diatomites may be classified as open water, but others likely reflect deposition in shallow water. Currently lacking magnetostratigraphy, we cannot be certain if these fall within the lower part of Chron C20n or the upper part of Chron C20r. If all IODP 396 and DSDP Leg 38 Paleogene diatomites are classified as OOS, the authors may be correct that middle Eocene open ocean diatomite accumulation recommenced ~43.5 Ma. But if they are classified as ES then their "gap" may need to be reduced.

The freshwater diatomite compilation does not seem to add much to the paper in terms of climatic controls, other than to note that volcanic input likely supports freshwater diatomite production and preservation. [A correlation between glassy ashes and preserved diatoms has been noted for decades (e.g., Blake, 1903; van Vleck Anderson, 1933; Bramlette, 1946).]

The introductory sections are useful and provide context, but include some discussion that is not directly supportive of the paper's theme. There is some ancillary yet still important commentary in acknowledging the potential limits of their dataset, including pointedly noting the small number of specialists working to generate high quality data on diatomaceous deposits. It is absolutely true that there is a plethora of diatom-rich sediments that have never been analyzed in any systematic way by diatom specialists, in large measure due to the lack of trained personnel, which goes back to the precipitous decline in funding for micropaleontological studies over the last several decades. Although often perceived as an "old-fashioned" science, these assemblages carry with them a vast amount of information regarding biostratigraphic age and paleoenvironments that could never be gleaned from single geochemical proxies. The limitations and uncertainties associated with diatom analysis have always been set by the low numbers of trained diatom workers. Many of us have been aging out, and the lack of career positions and resources is the sole barrier preventing growth among the next generation. I'm very pleased to see Cécile Figus and a few other young scientists addressing this problem. She and others will ensure continued important diatom science into the future. I hope hiring and funding sources will support a bright future for a new generation of fossil diatom scientists.

Technical Comments:

The paper is well-written with clear language and proper usage, with one potential exception. Although technically not incorrect, and admittedly a pet peeve of mine, frequent use of "*while*" (which implies the time domain: "during") would be better written as "*although"* (which is used to draw a contrast). There are one or two typos that I'm sure will be discovered in revision.

They note data availability on Zendos, but given that it's a small table, it should also be posted in Supplementary Materials. Furthermore, readers would really appreciate maps with interactive links to the data file, so we can easily identify each site locality.

Concluding Remark:
In conclusion, this is a very good paper, well researched and well worth publishing, though points noted above should be clarified and the manuscript tightened up. It is of appropriate scientific significance, scientific quality and presentation quality to justify publication as an *EGUSphere* contribution. In revision it should be made clearer that the paper is largely a compilation of available literature on Paleogene epicontinental diatomites, with some observations on similar-aged freshwater and open ocean deposits, and that the database is entirely focusing on terrestrially exposed materials, not on offshore coring. Supplementary materials should include the database linked to maps.

References cited:

Berndt et al., 2023. Shallow-water hydrothermal venting linked to the Palaeocene–Eocene Thermal Maximum. Nature Geoscience, 16(9), pp.803-809.

Blake, W. P. (1903). Arizona diatomite. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters*, *14*, 107.

Bramlette, M. N. (1946). *The Monterey Formation of California and the origin of its siliceous rocks* (Vol. 212). US Government Printing Office.

Planke, S., Berndt, C., Alvarez Zarikian, C.A., and the Expedition 396 Scientists, 2023. Mid-Norwegian Margin Magmatism and Paleoclimate Implications. Proceedings of the International Ocean Discovery Program, 396: College Station, TX (International Ocean Discovery Program). **https://doi.org/10.14379/iodp.proc.396.2023**

Schrader, H.J. and Fenner, J., 1976. Norwegian Sea diatom biostratigraphy and taxonomy. In, Talwani, M., Udintsev, G. et al., Init. Rep. DSDP, 38, pp.921-1099.

van Vleck Anderson, Robert. "The diatomaceous and fish-bearing Beida stage of Algeria." *The Journal of Geology* 41.7 (1933): 673-698.