

Dear Editor Dr. Antje Völker,

We are genuinely grateful for your detailed comments and careful checks for our manuscript. We have addressed all points and made the necessary revisions.

Below, we provide our responses. Please note that for minor wording edits and typographical corrections, we do not list individual responses. All such changes have been applied, and we have carefully rechecked the entire text for consistency and remaining issues.

Once again, we thank you for your time and thoughtful guidance.

All the best,

Volkan and co-authors

Line 55: I find underlying an awkward phrasing in this context. I suggest to use something like "resulting in" or "leading to".

Fixed. It now reads: "... the broader mechanistic mosaic **leading to** the E/O transition and Antarctic glaciation."

Line 65: A potential additional reference (since there are so few around related to diatoms) could be: Abrantes, F., Cermenio, P., Lopes, C., Romero, O., Matos, L., Van Iperen, J., Rufino, M., Magalhães, V., 2016. Diatoms Si uptake capacity drives carbon export in coastal upwelling systems. Biogeosciences 13, 4099-4109, doi: 10.5194/bg-13-4099-2016.

We thank you for this recommendation. We have now added it accordingly. We also note that this important work is cited in Section 4.2.

Line 85: latest would probably be better wording or "ending of the"

Fixed.

Line 88: If meant related to the stratigraphic subunits, both Mid(dle) and Late should be capitalized.

We have corrected all highlighted instances and carefully checked the manuscript to ensure consistent syntax of stratigraphic terms throughout the text.

Line 111: I would say you either analyzed the ...abundance or produced the .... abundance data

We fixed the highlighted part, it now reads: "We **generated** diatom and radiolarian abundance data from samples"

Line 123: I believe with the shortening of the introduction EOT as acronym has not been defined, yet. For easier reading E/O transition as you frequently use in the subsequent text might be the better solution and in that case you don't need to define another acronym.

Thank you. We have followed your recommendation and now use “E/O transition” consistently through the text.

Line 123: If you defined EOT as abbreviation you need to use it in the subsequent text like also two line below.

Please see our comment above.

Line 184: Check the syntax here; this incomplete sentence refer to what? number of samples for the MAR average and SD at Site 1090?

We corrected the unclear syntax and the corresponding part now reads:

“Site 1090 had an average diatom MAR of  $1.26 \times 10^7$  frustules  $\text{cm}^{-2} \text{kyr}^{-1}$  (standard deviation (std. dev.) =  $9.48 \times 10^6$ ; range:  $5.88 \times 10^5$  to  $3.26 \times 10^7$ ; total number of samples, N = 15).

Lines 222-229: This whole paragraph is discussion and not results! And you should provide a few details on the associated environmental conditions.

We agree that this paragraph was interpretive and overlapped with our later discussion (Sections 4.1 and 4.2) of these intervals. To avoid redundancy, we have removed it from the results section.

Line 285: May be insert here "plankton" to reiterate that (so far) your are discussing surface ocean data.

Added.

Line 289: May be replace peak with maximum, so that you don't always use the same wording

Replaced.

Line 299: not epsilon Nd data? if yes, please correct wording used here.

Fixed.

Line 308: verify that you defined this acronym (*SST*) before. I don't remember reading it.

Fixed.

Line 331: Since you used this phrase (*proto-ACC*) already above you should provide this information when you use it the first time.

Done. We have now introduced the full term “proto–Antarctic Circumpolar Current (proto-ACC)” at its first mention in the manuscript, Line 306.

Line 324: What do you mean by increasing circulation? Increased transport? Increased depth penetration of the proto-ACC (thicker ACC layer? wider ACC?)?

Thank you very much for pointing this out. The original text is indeed vague. We revised the sentence to clarify what aspect of circulation we mean. It now reads:

“...are interpreted here as a response to **the intensification of SO circulation, likely reflecting stronger eastward flow and enhanced vertical exchange within the developing proto-ACC system**, and **the associated increase** in nutrient distribution and upwelling.”

Line 360: if you use the phrase/ acronym only a few times in the manuscript I recommend to minimize the acronyms introduced in the text. Fewer acronyms to remember, especially those readers might not be so familiar with, makes following the text and arguments easier.

Thank you for this helpful note. We removed the acronyms for the Tasmanian Gateway and the Priabonian Oxygen Minimum.

Line 360: actually a shift from zooplankton to phytoplankton; so, a shift in primary productivity

Thank you for comment. We revised this section to clarify our interpretation. We now specify that the transition to a diatom-dominated regime around 33.5 Ma reflects a change in primary productivity and a more direct coupling between silica utilization and organic carbon export, rather than just an increase in opal deposition. This example highlights, once again, the importance of distinguishing the underlying sources of bulk opal records, which is one of the main motivation of our research.

It now reads: “This shift occurs while overall opal flux remains low in the Antarctic-adjacent sites, pointing to **a change in the biological source of silica, with production increasingly driven by diatoms. Such a transition implies a more direct coupling between silica utilization and organic carbon export, even under relatively low total fluxes.**”

Line 370: should be encapsulating but I also find the word choice awkward/incorrect. may be use encompassing

Done.

Line 405: Please provide some details, e.g., species richness increases from X to Y or H (Shannon) index increases from X to Y; a reader should not be forced to read your other manuscript in order to follow the argumentation in this manuscript..

Thank you so much for this point. In our recent work (Özen et al., subm.; <https://doi.org/10.31223/X50N1B>), we documented that SO diatom assemblages were far more diverse than previously recognized. Diversity increased notably across the Middle-to-Late Eocene transition and the Eocene/Oligocene boundary but was not uniform

throughout the entire Eocene/Oligocene transition. Overall, diatom assemblages appear at least five times more diverse than previously reported, revealing a highly dynamic and compositionally variable community structure. This observation aligns better with our argument in this paragraph that higher diversity corresponds to a broader range of ecological strategies (e.g, niche partitioning) and thus functional traits (e.g., Tréguer et al., 2018\*), leading to more efficient nutrient utilization, a key factor influencing biological pump. We have revised the text accordingly, which now reads:

**“Recent diversity reconstructions (Özen et al., subm.) show that Late Eocene-Early Oligocene SO diatom assemblages were at least five times more diverse than previously documented, revealing a pronounced increase in species richness and a highly dynamic community composition throughout this interval. Such diversity is expected to be positively associated with a broader range of functional traits within the community (Tréguer et al., 2018), and therefore with more efficient nutrient utilization, which is one of the operating terms of the biological carbon pump (Farmer et al., 2021).”**

\*Tréguer, P., Bowler, C., Moriceau, B., Dutkiewicz, S., Gehlen, M., Aumont, O., Bittner, L., Dugdale, R., Finkel, Z., Iudicone, D., Jahn, O., Guidi, L., Lasbleiz, M., Leblanc, K., Levy, M., and Pondaven, P.: Influence of diatom diversity on the ocean biological carbon pump, *Nature Geosci*, 11, 27–37, <https://doi.org/10.1038/s41561-017-0028-x>, 2018.

Line 427: May be look also at: Rigual-Hernández, A.S., Pilskaln, C.H., Cortina, A., Abrantes, F., Armand, L.K., 2019. Diatom species fluxes in the seasonally ice-covered Antarctic Zone: New data from offshore Prydz Bay and comparison with other regions from the eastern Antarctic and western Pacific sectors of the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* 161, 92-104, <https://doi.org/10.1016/j.dsro.2018.06.005>.

We thank you for suggesting this reference. We have now incorporated Rigual-Hernández et al., (2019) into the text to complement the modern ocean perspective on the relationship between diatom abundance diversity.

Line 462: Please give some specifics; see comment above; shifts from what type of community to what other type (or dominant species).

We revised the text to clarify the type of community shifts we are exactly referring to. It now reads: “Importantly, these productivity events coincide with **changes in dominant species composition and community structure** (Özen et al., subm.), **which** may have tuned the efficiency of the biological carbon pump (Tréguer et al., 2018).”