

REF2 comments

Review of “Variations in the Biological Pump through the Miocene: Evidence from organic carbon burial in Pacific Ocean sediments”

By Lyle and Olivarez-Lyle

Dear Editor,

The manuscript cp-2024-34 by Lyle and Olivarez Lyle follows up their earlier work published in 2006 “Missing organic carbon in Eocene marine sediments: Is metabolism the biological feedback that maintains end-member climates?”. In this paper, following the Metabolic Theory of Ecology, the authors for the first time introduced the idea that temperature dependency of metabolic rates may act as a positive feedback to the ocean biological carbon pump on geological time scales. They postulated that under warm climate conditions, such those in the Eocene, enhanced heterotrophs metabolic rates would increase organic matter remineralization in the water column leading to low organic carbon sequestered in deep ocean sediments, explaining lower than expected organic carbon accumulation rates in the equatorial Pacific at this time. This was a consequential paper in paleoceanography, spurring a wealth of studies aimed at investigating the efficiency of the biological pump under different climate states.

With a similar approach, in manuscript cp-2024-34, the authors focus on the trends of biogenic sedimentary components in the equatorial Pacific from about 21 Ma to present. They present new organic carbon and CaCO₃ percentages and accumulation rates from 5 sites and measurements of total Barium for 3 of them. They convincingly show a major shift in the pattern of sedimentation from low biogenic components between 21-14 Ma to higher and variable values from 14 Ma to present. Because the studied sites were always in an approximately equatorial position over the studied interval, a long term decrease in productivity starting at 14 Ma is not a likely explanation. Instead, the authors suggest changes in the efficiency of the biological pump due to the progressive cooling of upper ocean temperatures from the middle Miocene to modern.

I agree with their interpretation and think this is an interesting study which adds to the mounting evidences of a biological pump operating differently depending on background climate, and becoming progressively more efficient with the cooling trend of the last 15 Ma.

I think though, that the message of the paper would be much strengthened by a better contextualization of their data with coeval climatic trends. In particular:

- 1) The strong link that the authors suggest between the warmth of the Miocene Climate Optimum (17-14 Ma) and low sedimentation of biogenic components is not apparent from the dataset. The dataset shows low sedimentation of biogenic component also for the older interval between 21-17 Ma. Instead, what is really apparent is the increase in biogenic sedimentation from the late middle Miocene on. I would hence recommend the authors not to put so much emphasis on the MCO per se, but rather on the generally warmer early to middle Miocene climate compared to today.

We agree that the period prior to the MCO also shows poor preservation of POC and bio-SiO₂. We can rewrite the sections that discuss the results to make this point.

2) For the reason above, I also suggest the authors to show their data against climatic records covering the entire age range of their records. For instance, they could additionally show the sea surface temperature record from Auderset et al. 2022 /10.1038/s41586-022-05017-0 from 22 Ma on. This record shows an SST warming trend from about 22 Ma culminating in the MCO, which fits very well with the evidences shown here for low biogenic sedimentation over this whole time interval.

Thank you for the Auderset et al. 2022 reference. We have examined the Auderset data and have some concerns. In our review of the data, we found only 3 sites that are relevant to this study: i.e., both within the tropics and during the data period of the MCO. Second, before we would use these data, we would need to check the veracity of the stated paleolatitudes. For example, in their table Site 806 (Western Equatorial Pacific) remained at its current position (0.3 °N) for 20 million years. Using the Torsvik et al (2008) Euler rotations for the Pacific Plate, which we assume they have used, would place Site 806 at a paleolatitude of 4.9 °S at 20 Ma, vs 0.3 °N as reported in their table.

3) Using the mid-to low latitude SST record from Auderset et al. 2022, would also help going around the issue of presenting records from an equatorial region against Northern Hemisphere mid latitude temperatures as it is now, which is not ideal and I do not particularly like given other, more suitable records are available.

See the above comment—“low latitude” in the Auderset et al. figure was between 40N and 40S and true low latitude sites were few and far between.

Minor

1) I find confusing that the complete records of data generated are shown only for 2 of the measured sites (U1338 and U1337) (Figs. 3-4). Can you please have the same figure also for the other 3 sites for completeness and to allow an overview on the studied region?

We can provide illustrations in the supplemental material for Sites 574, 806, and 807. Unlike sites U1337 and U1338, we have only POC data and estimates of CaCO₃. There is no data for Ba or bio-SiO₂.

2) For the same reason I think the data from sites 884 and 1208 should also be shown in Fig. 2, although with the caveat that the sedimentary regime at these sites is less constrained.

We can add Sites 884 and 1208 to Figure 2 but feel that it is more appropriate to show only the equatorial sites.

3) A data availability statement is missing.

We plan to house the data at Pangaea.de after the paper is accepted. We can add this statement at the end of the text.

Typos:

We will fix these typos and any others found.

Line 37 the use of the word "eras" is a bit too colloquial.

Boscolo-Galazzo misspelled in lines 38 and 69.

Boscolo-Galazzo et al. 2018 missing in the reference list.

"Total" repeated twice in line 146.

Reference missing in line 383 for the sentence ending with "abyssal depth".

"Sediment" repeated twice in line 475.