

# ***Interactive comment on “A 15 million-year long record of phenotypic evolution in the heavily calcified coccolithophore *Helicosphaera* and its biogeochemical implications” by Luka Šupraha and Jorijntje Henderiks***

## **Anonymous Referee #1**

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Supraha & Henderiks present a nice new study of the morphological characteristics of modern cultured *Helicosphaera carteri* coccoliths, and how these parameters relate to each other and to cell physiological parameters (specifically PIC:POC ratios). They then go on to study the geological history and morphological evolution of the *Helicosphaera* group at two deep-sea coring sites, one in the oligotrophic tropical ocean and one at a higher-productivity mid-latitude site. The study provides an interesting insight into the Neogene evolution of *Helicosphaera* coccolith morphology and discusses potential drivers behind the trends, providing a new perspective when compared to ex-

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isting work on similar timescales based on the Reticulofenestra lineage. Overall, I think it is a timely and interesting paper that deserves to be published in Biogeosciences following some minor revisions. Specific comments are detailed below.

One general comment relates to the reported abundances of *Florisphaera profunda*. According to PP estimates in Fig 4, *F. profunda* coccoliths are present at quite stable and high levels (30% to >60% at Site 707) throughout the Miocene and Pliocene, back to 15 Ma at both sites. This is quite surprising. In my personal experience doing (low-latitude) biostratigraphy I have only observed this species as far back as the late Miocene (~7-8 Ma) and abundances by then were pretty low. Looking at the Nannotax range chart and other literature sources, these suggest an earliest first common occurrence of *F. profunda* around 8-10 Ma. So your results are really intriguing to me and I would like to know more! Are these Miocene *F. profunda* morphologically similar to the Plio-Pleistocene forms? Are you certain that you really have ~60% (equivalent to a PP of ~120 gC m<sup>-2</sup> yr<sup>-1</sup> using the Beaufort 1997 equation) relative abundances of this species in the middle and late Miocene at your Indian Ocean site? Another point related to the difference between the two sites: given the different temperature histories, I would suggest that this also contributes to the lower % *F. profunda* at site 525 (not just differences in productivity regime) – see this recent compilation paper: <https://www.sciencedirect.com/science/article/abs/pii/S0277379118306139>.

Comment on figures: I prefer the way you have displayed data in Figure S1 to the main figures (mean and 1 stdev). Maybe instead of the error bars, you could plot the original data behind the means? Or maybe use box and whisker plots or joy plots in the main figures? I just think that the way the data are currently displayed in the main paper does not do justice to all the measurements you did, or accurately show the range/distribution within each sample population. At the moment it looks like your data points have large “errors”, when in fact it is just that within-population variability is high. Figure s5 seems important to me, and maybe warrants promotion to the main text.

Abstract: I am not sure I fully understand the term “biogeochemical performance” – is

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this one that you are defining here for the first time or is this a commonly-used term in biology? You say that the fact that coccolithophores have a wide range of sizes and degrees of calcification implies that they have high “biogeochemical performance” – does this mean that they are more successful than other species that have smaller ranges of size etc? to me it just implies that they are highly adaptable so can thrive in different environmental conditions. I found this first sentence of the abstract a bit confusing.

Line 17-20: I suggest reversing these sentences so that you talk about the modern species first, then the fossil work.

Line 19: “which displays eco-physiological adaptations in modern strains” – reference missing

Line 21: state which physiological traits are you talking about – or use this term in line 2 (i.e. a wide range in physiological traits such as cell size, degree of calcification [ . . . ] ). Same with “physiological rates” – be specific what you are talking about.

Line 26: mean coccolith or cell size?

Line 38: Explain more clearly via what mechanisms coccolithophores “are still alleviating the negative effects of rising [ . . . ] CO<sub>2</sub> levels” Is this statement consistent with the following sentence?

Line 54: these 2 references don’t really represent all of the temperature and pCO<sub>2</sub> data out there.

57: There are also older references that show this size trend that should be included. Also. Bolton et al., 2016 does not reconstruct calcification rates (maybe states? degree of calcification?)

58: Middle Miocene to Pleistocene

89: I assume you mean not nutrient limited

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100: “Age models are based on calcareous nannoplankton biostratigraphy” – add references? Or is this your work?

105: reverse transparent and filters.

126: I would put this sentence at the end of the paragraph, once you have discussed all the complications, so the reader is left with the point that relative changes are still accurate. Also, perhaps important to note, did you see any temporal changes in the amount of coloured parts (thicker than 1.55µm) on *Helicosphaera* coccoliths?

158: modern cultured?

174: does local mean site-specific?

194: Not sure what “slightly negative allometry” means. It the cited figures thickness increases with area.

195: Sentences not clear. Are “phenotype dimensions” (of what?) and “mean coccolith traits” the same thing?

201: spelling error. Also replace specimens with coccoliths.

303: older references missing (ex. Young 1990)

Sentence line 327-329: I don’t follow this statement. . .

395: evolutionarily

Conclusion: the statement on millennial timescales seems to come out of the blue, I thought you had mainly discussed multi-million-year timescales? Maybe it would clarify if you added the references. I also think that your conclusions are quite general and vague, and could relate more to your finding in this study.

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